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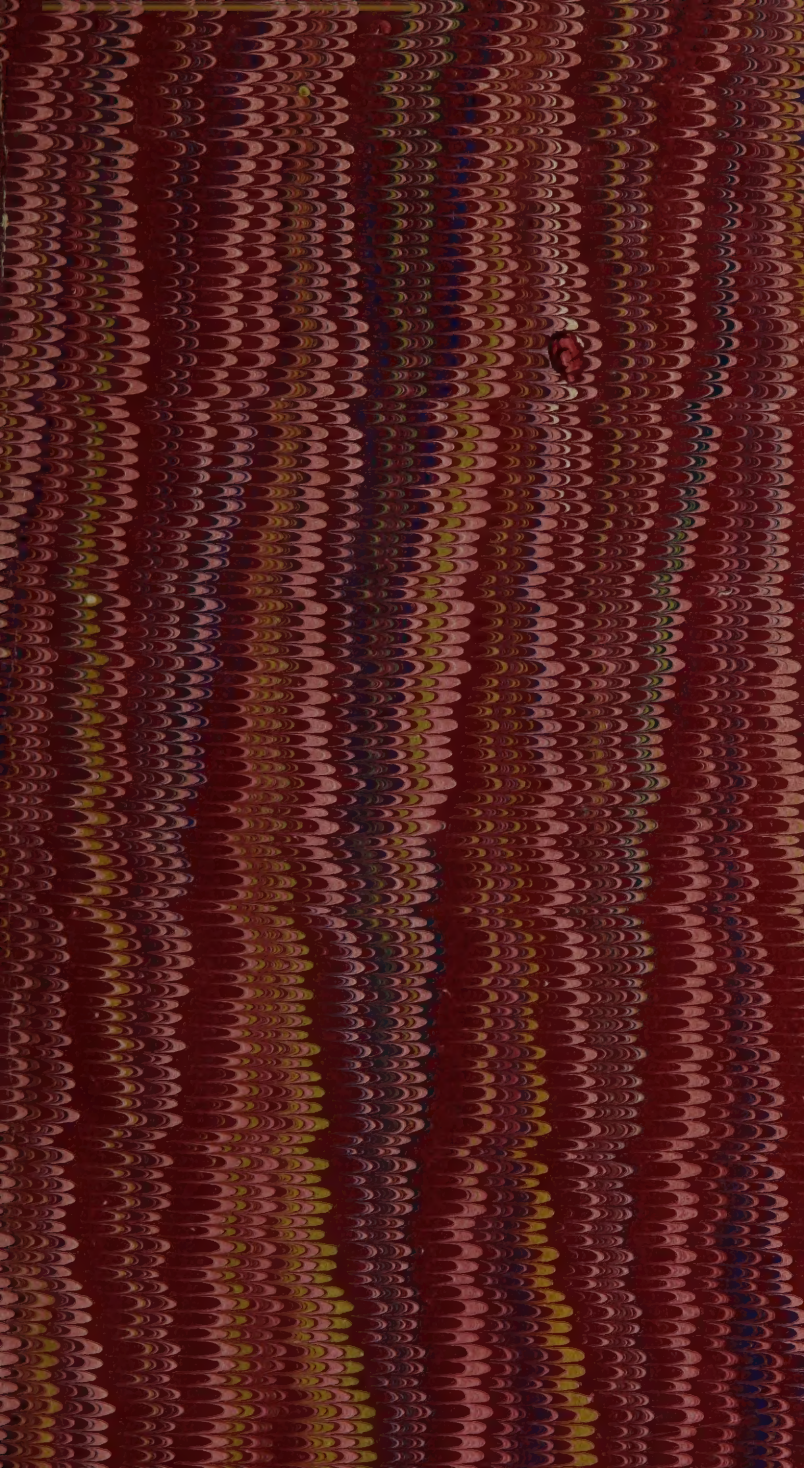
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MINUTES

John
of the
Crane

OF THE

COURSE OF CHEMICAL INSTRUCTION,

IN THE

Presented by
Mrs Dr Crane

MEDICAL DEPARTMENT

OF THE

UNIVERSITY OF PENNSYLVANIA,

BY

ROBERT HARE, M. D.

PROFESSOR OF CHEMISTRY.

PRINTED IN THREE PARTS,

FOR THE USE OF HIS PUPILS.

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MINUTES,

&c. &c.

ON THE RISE, PROGRESS, AND PRESENT STATE, OF CHEMISTRY
AS AN ART, AND AS A SCIENCE.

ON THE STUDY OF CHEMISTRY.

ON THE CAUSE OF THE PHENOMENA AND OPERATIONS OF THE
PHYSICAL WORLD.

REACTION between different portions of matter, is conceived to be the fundamental cause; for if there were no such reaction, every particle, or mass, would be as if no other existed.

REACTION,

Distinguished as taking place between masses, between a mass and particles, and between particles only.

REACTION BETWEEN MASSES,

Sublimely exemplified in the solar system.

REACTION BETWEEN A MASS, AND PARTICLES,

Exemplified by the reflection, refraction, or polarization of light; as by the moon, the rainbow, the Iceland spar.

REACTION BETWEEN PARTICLES, OR CORPUSCULAR REACTION,

Exemplified by a fire, or the explosion of gunpowder.

NATURAL PHILOSOPHY DEFINED.

In its most extensive sense, it treats of physical reac-

tion generally. In its more limited and usual acceptation, it treats of those phenomena, or operations of nature, which arise from reaction between masses, or between a mass and particles.

CHEMISTRY DEFINED.

It treats of the phenomena, and operations of nature, which arise from reaction between the particles of inorganic matter.

PHYSIOLOGY DEFINED.

Physiology treats of the phenomena and operations, which arise from reaction between the masses, or atoms, of organic, or living bodies.

THE REACTION OF PARTICLES, OR CORPUSCULAR REACTION,

Is distinguished into repulsive reaction, or repulsion, and attractive reaction, or attraction.

ATTRACTION,

Is distinguished, as it takes place between particles of the same kind, or homogeneous; and as it exists between particles of a different kind, or heterogeneous.

The attraction which takes place between homogeneous particles, is designated as attraction of aggregation, of cohesion, or homogeneous affinity. The attraction which arises between heterogeneous particles, is called chemical affinity, or heterogeneous affinity.

ON ATTRACTION OF AGGREGATION, OR COHESION: ALSO CALLED HOMOGENEOUS AFFINITY.

It is the force which resists mechanical division. Overcoming it, does not alter the *chemical* nature of a substance. It is the cause of crystallization.

CRYSTALLIZATION,

Is that process of nature, by which bodies, passing from the fluid to the solid state, assume regular forms called crystals.

CRYSTALS,

Are found in nature, and are produced artificially.

EXAMPLES OF NATIVE CRYSTALS.

The precious stones are splendid productions of this kind. Calcareous spar, common salt, gypsum, are native products, often crystalline in form.

ON THE VARIOUS MEANS OF CAUSING ARTIFICIAL CRYSTALLIZATION.

Fusion followed by congelation.—Instances: Sulphur, bismuth, antimony, zinc.

Solution followed by evaporation in open vessels.—Exemplified by salts, acids, alkalies, sugar.

Solution with heat followed by refrigeration.

Most of the substances which yield crystals by the process last mentioned, yield them likewise in this way.

Solution followed by vaporization at the boiling heat.—

Crystals may be thus obtained from many salts; but are always minute.

Solution followed by saturation.—Instances: Pearl ash saturated by carbonic acid or chlorine.

Sublimation.—This comprises the idea of vaporization and condensation. Instances: Corrosive sublimate, calomel, iodine, arsenic.

Solution followed by precipitation.—Arbor Dianæ, arbor Saturni.

SUBJECT OF CRYSTALLIZATION CONTINUED.

Other things being equal, the slower their growth, the larger the crystals. Granular texture of the trap rocks, attributed to slow cooling. Curious effects of excluding air from a solution of Glauber's salt, after boiling it down. Influence of agitation. Congelation hastened by it. Crystals shoot in preference from extraneous bodies, as, for instance, from strings or sticks. All matter presumed capable of crystallizing.

RATIONALE OF THE PROCESS OF CRYSTALLIZATION.

OF THE OBSERVATIONS OF ROME DE LISLE, OF GAHN, OF BERGMAN, OF HAUY.

OF HAUY'S CRYSTALLOGRAPHY.

OF THE ATTRACTION, WHICH OPERATES BETWEEN HETEROGENEOUS PARTICLES; CALLED AFFINITY, OR HETEROGENEOUS AFFINITY.

This attraction, unless where it is nearly balanced by the opposite power of repulsion, is never overcome by mechanical means.

DIFFERENT CASES OF AFFINITY, ACCORDINGLY AS MORE OR FEWER PARTICLES ARE CONCERNED.

1ST CASE—SIMPLE COMBINATION.

A and B, two heterogeneous substances united in the compound AB. Instances:

Copper and zinc form	Brass.
Lead and tin form	Pewter.
Oil and alkali form	Soap.
Acids and alkalies form	Salts.
Chlorine and metals form	{ Chlorides, as for instance calomel or corrosive sublimate.
Sulphur and metals form	
	Sulphurets.

2D CASE OF AFFINITY.

Simple combination, attended by decomposition, called simple elective attraction, or affinity.

A and B, two heterogeneous particles, being united in compound AB.—C, another particle, being blended with them in solution, unites with one of them as A, to the exclusion of B.

In this case, C is said to decompose AB, and to have a greater affinity for A than B.

Instances of simple elective affinity.

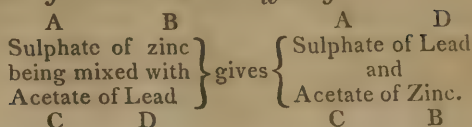
Nitrate {	of Silver decomposed by	Mercury.
	of Mercury decomposed by	Copper.
	of Copper decomposed by	Iron.
Muriate of Lime decomposed by		Sulphuric Acid.
Sulphate of Alumine decomposed by	{	Potash.
Sulphate of Magnesia decomposed by		

3D CASE OF AFFINITY,

Called double elective attraction, or complex affinity. A double combination, attended by double decomposition.

The compound formed by the particles A and B, being blended in solution with the compound formed by C and D,—A combines with D, and B with C.

Instance of double elective affinity.



VARIOUS OTHER EXPERIMENTAL ILLUSTRATIONS.

4TH CASE OF AFFINITY.

A, B, and C, being in union, on adding D, it combines with B, which it would not do were not C present.

Instance.—Ammoniacal nitrate of copper, or silver, added to a solution of white arsenic in water. The arsenious solution will not per se decompose the nitrates.

5TH CASE OF AFFINITY.

A and B, being in union, C added in *excess*, combines with both A and B.

Instance.—Ammonia added to solutions of copper, or silver, gold, &c.

ON COHESION AS AN OPPONENT OF CHEMICAL COMBINATION.

EFFECT OF MECHANICAL DIVISION.

Action of an acid upon a lump of metal, and upon the same in filings. Influence of solution. Tartaric acid and a carbonate do not react, when mixed, until moistened.

EXCEPTION TO THE LAW THAT CHEMICAL ACTION REQUIRES FLUIDITY.

Action of lime upon muriate of ammonia.

ON TABLES OF AFFINITY.

Any substance being placed at the head of a column, other substances are placed under it in the order of their attraction for it.

AN EXAMPLE.

SULPHURIC ACID.

Barytes,
Strontites,
Potash,
Soda,
Lime,
Magnesia,
Ammonia.

ON DEFINITE PROPORTIONS.

The proportions have been long known to be invariable, in which substances must be mixed, in order to saturate each other; or to produce a compound, in which the peculiar characters, or affinities of the ingredients are extinguished.

When substances combine in other proportions than those of saturation, their ratio is no less definite, and constant.

There is not, in any case, except the peculiar one of solution, an indefinite gradation in the proportions in which bodies combine. There are rarely more than four gradations.

The number, representing the least proportion in which a substance is known to combine, will almost always divide the numbers representing the greater proportions, without a fraction.

Let A, B, and C, be certain substances, and let X, Y, and Z, be other substances, severally having an affinity for either A, or B, or C. Let each of the former, and each of the latter, be combined in the least possible proportion. Consequently the least combining proportion of each substance, will be found three times. It will appear that the proportions of A, B, and C, found by combining them with X, will be in the same ratios to each other, as the proportions found by combining them with Y, or Z, and reciprocally, that the proportions of X, Y, and Z, will have the same ratios, whether ascertained by their combination with A, B, or C. This uniformity of the ratios existing, between the least combining proportions of substances, will be found to prevail, if instead of six substances, the comparison be made with any larger number.

Chemical equivalents are numbers, representing the least combining proportions of the substances to which they belong. They are usually assumed so, as either to make the equivalent of hydrogen, one, or that of oxygen, ten.

TABLES OF CHEMICAL EQUIVALENTS,

Are very useful; for as the equivalent number of any compound, is to any weight of the compound, so is the equivalent of either of its ingredients, to the quantity of such ingredient in the said weight of its compound.

WOLLASTON'S SCALE OF EQUIVALENTS.

By this, the computations requisite in using the equivalents, are performed by a slide, which operates on a well known mathematical principle.*

THEORY OF ATOMS.

The ratio of the equivalent numbers, supposed to be dependent on, and identical with, that of the integral atoms of the substances to which they appertain.

Probability that there are elementary atoms, indivisible either by mechanical, or chemical means. Mechanical division, limited by the imperfection of edges, or surfaces. Were atoms chemically divisible, ad infinitum, any one substance, however small in quantity, would be equally diffusible throughout any other, however great. The fact is otherwise, whence, elementary atoms are inferred to be chemically indivisible.

BINARY COMPOUNDS.

A compound, in which the ingredients are both reduced to the smallest possible proportions, is considered as having as many atoms of the one as of the other; and each integral atom of the compound, as consisting of an atom of each ingredient. Such combinations are called binary, because they contain but two atoms.

TERNARY COMPOUNDS.

When the quantity of either ingredient is the double of its least proportion, it is supposed that the number of its atoms is doubled; and the other ingredient being in its least proportion, it is inferred that there are two atoms of the former to one of the latter: hence it has been called a ternary compound.

QUATERNARY COMPOUNDS,

Are those, in which the proportion of one of the ingredients is tripled, so that it is supposed to contain four atoms.

* The equivalents may be expressed in any numbers having the same ratios to each other as the least proportions of the substances which they represent. The slide enables us to adopt such other numbers as may be convenient. Equal distances on the slide, give the same ratios in different numbers. If, by moving the slide, we vary one equivalent, to 100 for instance, the other equivalents vary proportionably.

ON CALORIFIC REPULSION.

A PRIORI PROOFS, THAT THERE MUST BE A MATTER, IN WHICH REPULSION EXISTS AS AN INHERENT PROPERTY.

The existence of repulsion and attraction between the particles of matter, is as evident as that they exist. Opposite qualities, cannot belong to the same particles. There must be particles, in which repulsion is inherent, as well as others in which attraction is inherent.

EXPERIMENTAL PROOFS, OF THE EXISTENCE OF A MATERIAL CAUSE, OF CALORIFIC REPULSION.

Ice at 32° , mixed with water at 170° ,—mixture, when ice is melted, 32° . Water at 32° , mixed with water at 170° ,—mixture, at a mean heat. Water exposed to a fire, does not grow hotter after it boils, but steams more or less, according to the activity of the fire. The steam appears to carry off the caloric. Steam, at the temperature of 212° , will heat, by its condensation, nearly ten times its weight of cool water 100 degrees. Inference from this effect.

OF THE TERM CALORIC.

Propriety of using a new word (caloric) to designate the material cause of calorific repulsion, illustrated by a fulminating powder, which, though cold, contains more of the material cause of heat, than red-hot sand.

ORDER PURSUED IN TREATING OF CALORIC.

OF ITS EFFECTS. ON THE MODIFICATION OF THE EFFECTS OF CALORIC BY ATMOSPHERIC PRESSURE. MEANS OF PRODUCING HEAT, OR RENDERING CALORIC SENSIBLE. ON THE COMMUNICATION OF HEAT. SLOW COMMUNICATION: QUICK COMMUNICATION. MEANS OF PRODUCING COLD, OR RENDERING CALORIC LATENT. ON THE VARIOUS STATES, WHEREIN CALORIC EXISTS IN NATURE.

EXPANSION, THE MOST OBVIOUS, AND UNIVERSAL EFFECT, OF CALORIC.

ON THE EXPANSION OF SOLIDS. ON THE EXPANSION OF LIQUIDS. ON THE EXPANSION OF ELASTIC FLUIDS. ON THE OPPONENT AGENCY OF ATMOSPHERIC PRESSURE.

EXPANSION OF SOLIDS.

A ring and plug, which, when cold, fit each other, cease to do so when either is heated: and a *red-hot* tire goes on

a wheel, otherwise, too large for it. A pyrometer shown in which expansion is multiplied by levers. Metals, the most expansible solids, but unequally so.

SUPPOSED EXCEPTION TO THE LAW, THAT SOLIDS EXPAND BY HEAT, IN THE CASE OF CLAY; WHICH CONTRACTS IN THE FIRE.

The clay loses bulk, by losing water. Granular aggregates sink before fusion. Each grain may expand, while the mass contracts. The size of the masses after their greatest contraction, probably would be found, in proportion to their temperature.

WEDGWOOD'S PYROMETER EXHIBITED.

The contraction, induced in cylinders of clay, in proportion as they have been heated, measured by a scale, indicates the heat to which they have been exposed.

EXPANSION OF FLUIDS, WHICH ARE ALMOST INCOMPRESSIBLE OR NON-ELASTIC, AS WATER, OIL, ALCOHOL.

For the sake of brevity these will be called liquids.

LIQUIDS MORE EXPANSIBLE THAN SOLIDS.

Expansion of liquids, shown by matrasses with long narrow necks, filled to the origin of their necks with fluids variously coloured.

A THERMOMETER,

Is a small matrass having a scale attached to a long narrow neck, containing some liquid. Original instrument by Sanctorio, or Van Helmont, defective from its sensibility to barometrical changes. Of mercurial and spirit thermometers. Mode of filling them, of graduating. Freezing and boiling of water, with due regard to the barometer, the standard points on the scale. Distance between those points, divided by Celsius into 100°, by Reaumur into 80°, and by Fahrenheit into 180°. The freezing point in Fahrenheit, improperly at 32°: properly at zero in the others.

SELF-REGISTERING THERMOMETERS. PALM GLASS

DIFFERENTIAL THERMOMETERS.

EXCEPTION TO THE LAW THAT LIQUIDS EXPAND BY HEAT

Between freezing and 40° of F. water contracts. Ice one-ninth more bulky than the water forming it. But for these properties of water, lakes and rivers might freeze to a depth destructive of aquatic animals, and so as not to thaw in summer.

EXPANSION OF ELASTIC FLUIDS.

DEFINITION OF ELASTICITY.

Power of resuming shape, position, or bulk, on the cessation of constraint. Degree of it not dependent on the force, but on the *perfection* of recoil. A watch spring, not less elastic than a coach spring. Atmospheric air, and all other æriform fluids, perfectly elastic. Elasticity erroneously spoken of as a varying property in air.

The bulk of æriform fluids regulated by pressure as well as heat.

MODIFICATION OF THE EFFECTS OF CALORIC BY ATMOSPHERIC PRESSURE.

DIGRESSION TO DEMONSTRATE THE NATURE AND EXTENT OF ATMOSPHERIC PRESSURE.

The pressure on any assumed area, within any given fluid, is equivalent to a column of that fluid, whose base is the area assumed, and whose height is equal to the depth of the area below the surface. This is more obvious, where the area is horizontal, and the column vertical, which is in point.

On the same assumed area, within the given fluid, a column of any other fluid may be substituted, without altering the equilibrium; making it as much higher, as lighter, or as much lower, as heavier.

ILLUSTRATION.

A long tube of glass, open at both ends, with a crook at one end occupied by mercury. The crooked end being lowered into a tall vessel of water; mercury rises in the tube, (in consequence of the pressure of the water, or its effort to enter the tube), in proportion to the depth; and its height will be as much less than the depth to which it may be sunk in the water, as it is heavier than the water.

A FURTHER ILLUSTRATION.

A glass jar, about 30 inches high, with mercury occupying the bottom to the height of about two inches. Within the jar several glass tubes, of about $1\frac{1}{2}$ inches in diameter, are placed upright, both ends open, and rising above the jar about $\frac{1}{3}$ d of its height: on pouring water into the jar, the mercury rises in the tubes nearly an inch for every foot of water added. Into each of the tubes successively, water, alcohol, ether, brine, are introduced, until the mercury in each tube, sinks to a level with the mercury without. The columns of the fluids are severally, as much higher than the water, as they are lighter; as much lower than the water, as they are heavier: or their heights are inversely as their gravities.

Immaterial how light the fluid be, provided it have weight, and that its height be as much greater, as its weight is less. Raising balloons, proves the air to have weight. Air cannot be used in the above illustration; since the tubes are already filled with it, and their height insufficient.

Having in water, substituted mercury, for water; in air, let mercury be substituted for air. This object is effected, by filling and inverting a tube, sealed at one end, and open at the other, in a reservoir of mercury. The mercury will be supported vertically in the tube, if long enough, between 27 and 30 inches, and no higher. Mercury, sustained by the pressure of the air on the surface of the reservoir, and by its height, measures that pressure. Pressure on the superficies of the whole earth the same, and of course equal to that which would be caused by a stratum of mercury, nearly 30 inches in depth; or about fifteen pounds for each square inch.

DIFFERENCE BETWEEN PUMPING AN ELASTIC FLUID, AND A NON-ELASTIC FLUID, SHOWN BY MEANS OF A GLASS SUCTION PUMP WITH GLASS TUBULATED RECEIVER.

Admission of air necessary to the suction of the water from the receiver. Air may be removed by the same process from *close* vessels. Water rises by pressure of the atmosphere. Air presses out by its own elasticity.

ACTION OF THE AIR PUMP SHOWN, BY MEANS OF GLASS CHAMBERS.

ACTION OF THE CONDENSER EXPLAINED.

EXPERIMENTS WITH THE AIR PUMP.

Gum elastic bag or bladder, partly distended and closed, subjected to air pump: also, a vessel partly filled with water, inverted in mercury in a jar: also, a sealed tube, filled with, and inverted in mercury, in a bottle. Tube similarly situated, containing air only.

FURTHER PROOFS OF THE WEIGHT OF THE ATMOSPHERE.

Glasses for showing unresisted pressure on the hand; on a bladder; on Otho Guericke's brass hemispheres; on a square bottle. Proof that the pressure arising from elasticity within, is equal to the pressure without. Square bottle broken under receiver, by exhaustion of air from within, or from without.

The height of the column of mercury which balances the atmosphere, shown by exhaustion. Result compared with Torricellian experiment.

PROCESS OF RESPIRATION.

Elevation of the sternum, rarefies the air in the cavity of the thorax. The atmospheric pressure, not being balanced, the air rushes through the trachea into the lungs, dilating all its cells. The depression of the sternum and diminution of the cavity, causes the air which had thus entered, or an equivalent portion, to flow out.

ON THE ALTITUDE OF THE ATMOSPHERE.

If of uniform density, its altitude as much greater than 30 inches, or the height of the column of mercury shown adequate to counterbalance it, as air is lighter than that fluid. Mercury 11450 times heavier than air. Hence the atmosphere, if uniformly dense, 11450 times higher than 30 inches, or 343500 inches, or 28625 feet. Not much more than the height of the Andes.

The pressure of the atmosphere, being the cause of its density, it varies with the elevation.

EXPANSION OF ELASTIC FLUIDS,

Sufficiently intelligible, from the experiments and observations already made. Their volume appears to be inversely as the pressure to which they are subjected, and directly as the heat.

SPECIFIC HEAT, AND THE CAPACITIES OF SUBSTANCES FOR HEAT.

Effects of equal weights of different substances, equally cool, (added successively to equal quantities of hot water at the same degree of heat,) in lowering the temperature, will be found very different. Thus the effect of a given volume of water being 1000, the effect of a like volume of glass will be 137; of copper 114; of tin 60; and of lead 42; and if equal bulks be tried, the effect of copper, 1027, glass, 448, lead, 487, tin, 444. If equal weights of water and mercury at different temperatures be mixed, the effect on the water will be no greater, than if instead of the mercury, 1-28 of its weight of water had been added; and it takes twice as much mercury by measure, as of water heated to the same point, to have the same influence.

APPARATUS TO ILLUSTRATE CAPACITIES FOR HEAT.

The specific heat of bodies is, of course, always as their capacities for heat.

ON THE COMMUNICATION OF HEAT.

SLOW COMMUNICATION. RADIATION.

Slow communication. { Conducting process.
 { Circulation.

ILLUSTRATION OF THE CONDUCTING POWER OF SOLIDS.

Hold one end of a brass pin in the fingers, the other in a candle flame.

ON INEQUALITY OF CONDUCTING POWER.

Effect of the pin compared with that of a splinter of wood, or a glass filament of the same size. Cement them severally at one end to a stick of sealing wax, and heat them at their other ends.

Fracture of glass and porcelain, exposed to fire, is the consequence of an inferior conducting power; as the heat is not distributed with quickness enough, to prevent inequality of expansion. Hence thin glass bears heat, better than thick.

Glass may be divided by a heated iron ring; or by a string steeped in oil of turpentine and fired, or by the heat generated by friction.

METALS BY FAR THE BEST CONDUCTORS.

Silver and copper, among the best conducting metals. Lead and platina, among the worst.

CALORIC PROBABLY EXISTS IN METALS, AS AN ESSENTIAL CONSTITUENT.

Process by which it may be conducted by them.

ON THE CONDUCTING PROCESS, IN LIQUIDS.

PROOF THAT LIQUIDS, ARE ALMOST DEVOID OF THE POWER TO CONDUCT HEAT.

Through a cork in the pipe of a glass funnel, nearly filled with water, pass the stem of an air thermometer, (bulb uppermost,) till within about a fourth of an inch of the surface of the water. Over the water pour ether, and inflame it. The thermometer will not be affected by the heat of the flame, though sensible to a slight touch from the finger, even while under the water.

PROOF THAT HEAT, MAY IN SOME DEGREE BE CONDUCTED BY LIQUIDS.

Reference, to Murray's experiment with a vessel of ice.

PROCESS, OF COMMUNICATING HEAT BY CIRCULATION.

A glass tube, sealed at one end, and filled with water, is slightly inclined. The flame of a spirit lamp is applied to the upper part, within about two inches of the surface of the water. Water, coloured by litmus, poured through a tube so as to occupy the bottom. The water boils at top, while the portion below the lamp is not heated, nor the litmus disturbed. The flame being shifted to the bottom of the tube, the heat and the dye are diffused upwards

throughout the tube, till they meet with the portion previously warmed by the lamp.

Water in glass vessel, with pieces of amber. Lamp applied. Circulation shown by the amber.

QUICK COMMUNICATION OF CALORIC, OR RADIATION.

Heat from a fire, received in opposition to the draught, as in roasting and toasting, is the effect of radiant caloric. A kettle placed over a fire, receives heat both by radiation, and the conducting process. Caloric proceeds in rays, or radii, from every body warmer than the surrounding medium, and towards every one which is colder. Radiant heat reflected, by bright metallic surfaces, agreeably to the same laws as light, and may be collected in a focus, in a like manner.

Rays which come to a concave mirror, parallel to each other, proceed to its focus. Rays proceeding from a body in the focus, after meeting the mirror, proceed from it parallel to each other, and may be made to fall on another concave mirror, and concentrate themselves in its focus. Experimental proofs of this property in the rays of heat. Matraass with boiling water in one focus, affects a differential thermometer in the other. Phosphorus ignited at twenty, and even at sixty feet, by an incandescent cannon ball.

RADIATION OF COLD, SO CALLED.

Snow-ball placed near mirror, produces cold enough in the focus to be detected.

RATIONALE.

ON THE DIFFERENCE OF POWER, IN DIFFERENT SUBSTANCES, TO RADIATE, OR REFLECT HEAT.

The best conductors, the worst radiators, and vice versa.

Cubical canister, having one side coated with charcoal, another with writing paper, a third with a pane of glass, the fourth uncovered: Effect of the charcoal on a thermometer in focus of mirror, as 100, of the paper as 98, of the glass as 90, while the effect of the metal only as 12.

Thus, metals which conduct best, radiate worst; and

charcoal, which is one of the worst conductors, is the best radiator.

RATIONALE OF THE DIFFERENCE OF CONDUCTING POWER, AND RADIATING POWER, IN METALS, CHARCOAL, GLASS, POTTERY.

WORST RADIATORS, BEST REFLECTORS.

Same constitution which prevents radiation, causes reflection. When so near the fire as that the hand, placed on them, is scorched intolerably in a few seconds, brass and irons do not grow hot, during exposure to it, from morning till night.

To preserve heat, in air, or to refrigerate, in water, vessels should be made of bright metal. Fire places should be constructed of a form and materials, to favour radiation: flues of materials to favour the conducting process.

MEANS OF PRODUCING HEAT, OR RENDERING CALORIC SENSIBLE.

Solar beams. Lenses, mirrors. Burning of the Roman ships by Archimedes. Buffon's experiments.

ELECTRICITY.

Lightning. Electric spark. Electrophorus.

GALVANISM

Substitute for the electrophorus. Deflagrator.

COLLISION, OR ATTRITION.

Flint and steel. Rotatory match box. Steel mill for light. Pieces of quartz rubbed. Metals heat in drilling or turning.

PERCUSSION.

A rod of iron rapidly hammered, ignites a sulphur match; and phosphorus, more easily. Coin grows hot when struck by the coining press; but, if repeatedly struck, and cooled at each succeeding stroke, it is less heated each time.

FRICTION.

Savages ignite wood by rubbing sticks together. Carriage wheels, by rapid motion, take fire. Glass phial heated by friction, so as to separate into two parts, on immersing it in water.

CONDENSATION.

Condenser for igniting spunk or tinder.

COMBINATION.

Boiling heat produced, by mixing sulphuric acid with water. Ignition produced by water and lime. Combustion of platina with tin foil.

SOLUTION.

Produces either heat, or cold, according to the nature of the substance dissolved, and solvent employed. Nitric acid grows warm, in acting on silver, or copper; and still more so on tin.

Water becomes cold, in dissolving nitre.

CHEMICAL COMBINATION, ATTENDED BY DECOMPOSITION.

Sulphuric and nitric acids, ignite oil of turpentine. Sulphuric acid produces ignition with the chlorate of potash, mingled with almost any very combustible matter, as turpentine, alcohol, sugar, and even ignites phosphorus under water. Combustion of tin foil with moistened nitrate of copper.

MECHANICAL ACTION, INDUCING CHEMICAL DECOMPOSITION.

Fulminating powder exploded by percussion.

METHODS OF SUPPORTING HEAT, FOR THE PURPOSES OF CHEMISTRY.

Principle of air furnaces: of Argand's lamp; and of the forge fire. Portable furnaces. Cupelling furnace. Small furnace with a drawer. Lamp without flame.

BLOWPIPE.

Mouth blowpipe; method of using it; great utility. Enameller's lamp. Alcohol blowpipe.

COMPOUND BLOWPIPE.

Fusion and combustion of iron, steel, platina, copper, &c.

ON THE MEANS OF PRODUCING COLD, OR RENDERING CALORIC LATENT.

ON THE STATES IN WHICH CALORIC EXISTS IN NATURE.

ESSAY ON THE QUESTION WHETHER CALORIFIC REPULSION CAN BE DUE TO MOTION.

IMPORTANCE OF THE SUBJECT OF HEAT, OR CALORIC, TO THE PHYSIOLOGIST.

There is neither any body, nor any process, chemical or vital, in which its secret or obvious agency is not to be perceived or detected.

In no characteristics are chemical processes so analogous to those of life, as in their inseparable association with caloric, as a cause, or consequence.

Seeds and eggs, lie dormant till warmed.

CONCLUDING ADDRESS, ON THE SUBJECT OF CALORIFIC REPULSION.

ON LIGHT, OR THE MEDIUM OF SIGHT.

Conceded by a majority of philosophers to be material. Opinions of Huygens and Euler, and of Newton. Latter, probably right.

VELOCITY OF LIGHT.

Comes from the sun, ninety millions of miles in eight minutes, or at the rate of two hundred thousand miles in a second.

INCONCEIVABLE MINUTENESS OF LIGHT.

Loss of weight in the combustion of tallow, which can be ascribed to the escape of light, inappreciable; yet enough emitted by a tallow candle, to produce sensation in many hundred millions of eyes. A sphere of rays, emitted from every visible point in the universe, in radius equal to the distance at which that point is to be seen.

REFLECTION OF LIGHT.

REFRACTION OF LIGHT. DISPERSION OF LIGHT.

DIAGRAMS AND FIGURES TO EXPLAIN.

OF THE INVISIBLE RAYS OF THE SPECTRUM.

ON THE HEATING RAYS, ILLUMINATING RAYS, AND DEOXYDIZING RAYS.

POLARIZATION OF LIGHT—BY REFRACTION—BY REFLECTION.

ON THE SOURCES OF LIGHT.

The sun. Combustion. Decomposition without heat, as in light wood. Electricity. Galvanism. Life—as by the fire fly, or glow worm.

ON THE EFFECTS OF LIGHT.

ON SPECIFIC GRAVITY.

Clear conception of it necessary, to a comprehension of the language of the most useful sciences and arts. May be defined, the ratio of the number expressing the weight of a body, to the number expressing its bulk. All processes reducible to two—ascertaining weight of known bulk, or bulk of known weight. When masses are reducible to same bulk, only necessary to weigh them. When reducible to same weight, only necessary to measure them. If water were among a number of substances reduced to same bulk, and weighed, and its weight assumed as a unit, the numbers found would be the same as those now in use to express specific gravities. Gravity of water assumed as the standard weight, because easily accessible in state sufficiently pure; and the weight, of bodies is easily compared with the weight of an equal bulk of it.

In order to obtain the specific gravity of a body, therefore, we have only to divide its weight, by the weight of a quantity of water equal to it in bulk.

The weight of a quantity of water, equal to the body in bulk, is equal to the resistance which the body encounters in sinking in water. Hence, if we can measure the resistance which a body encounters in sinking in water, and divide the weight of the body by it, we shall have its specific gravity.

*5009. 10000 grains = 1 lb
270. 3600*

In the case of a body which will sink of itself, the resistance to its sinking, is what it loses of its weight, when weighed in water.

In the case of a body which will not sink of itself, the resistance to its sinking, is its weight added to the weight which must be used to make it sink.

PRACTICAL MEANS OF ASCERTAINING THE RESISTANCE TO A BODY'S SINKING IN WATER, EXHIBITED.

Scale beam. Nicholson's hydrometer. Steelyard by Lukens and Coates.

TO ASCERTAIN THE GRAVITY OF A LIQUID.

Weigh glass globe, of known weight, first in pure water and then in the liquid. As loss in first instance, to loss in the last, so 1000, to gravity sought. If the ball loses in water 1000 grs. the answer for any other fluid is the number of grains which it loses in that fluid. Or in a vessel which will hold 1000 grs. of water, at 60° F. weigh as much of any other fluid as will fill it. The weight in grs. is the gravity sought. In like manner the gravity of granular masses found.

HYDROMETERS. SACCHAROMETERS, FOR ALCOHOL, AND FOR SALINE, AND OTHER SOLUTIONS. ALSO, FOR VEGETABLE INFUSIONS.

In these a constant weight is used, (to a certain extent,) and the differences of gravity estimated, by the quantum of the stem immersed. In those instruments of this construction, where several weights are employed, the effect of these is the same, as if the stem of the instrument were lengthened as many times, as the number of the weights attached to it.

ON THE NECESSITY OF A STANDARD TEMPERATURE FOR HYDROMETRICAL OBSERVATIONS.

END OF PART I.

Y. C. C.

MINUTES
OF THE
COURSE OF CHEMICAL INSTRUCTION,
IN THE
MEDICAL DEPARTMENT
OF THE
UNIVERSITY OF PENNSYLVANIA,

BY
ROBERT HARE, M. D.

PROFESSOR OF CHEMISTRY,

PRINTED IN THREE PARTS,

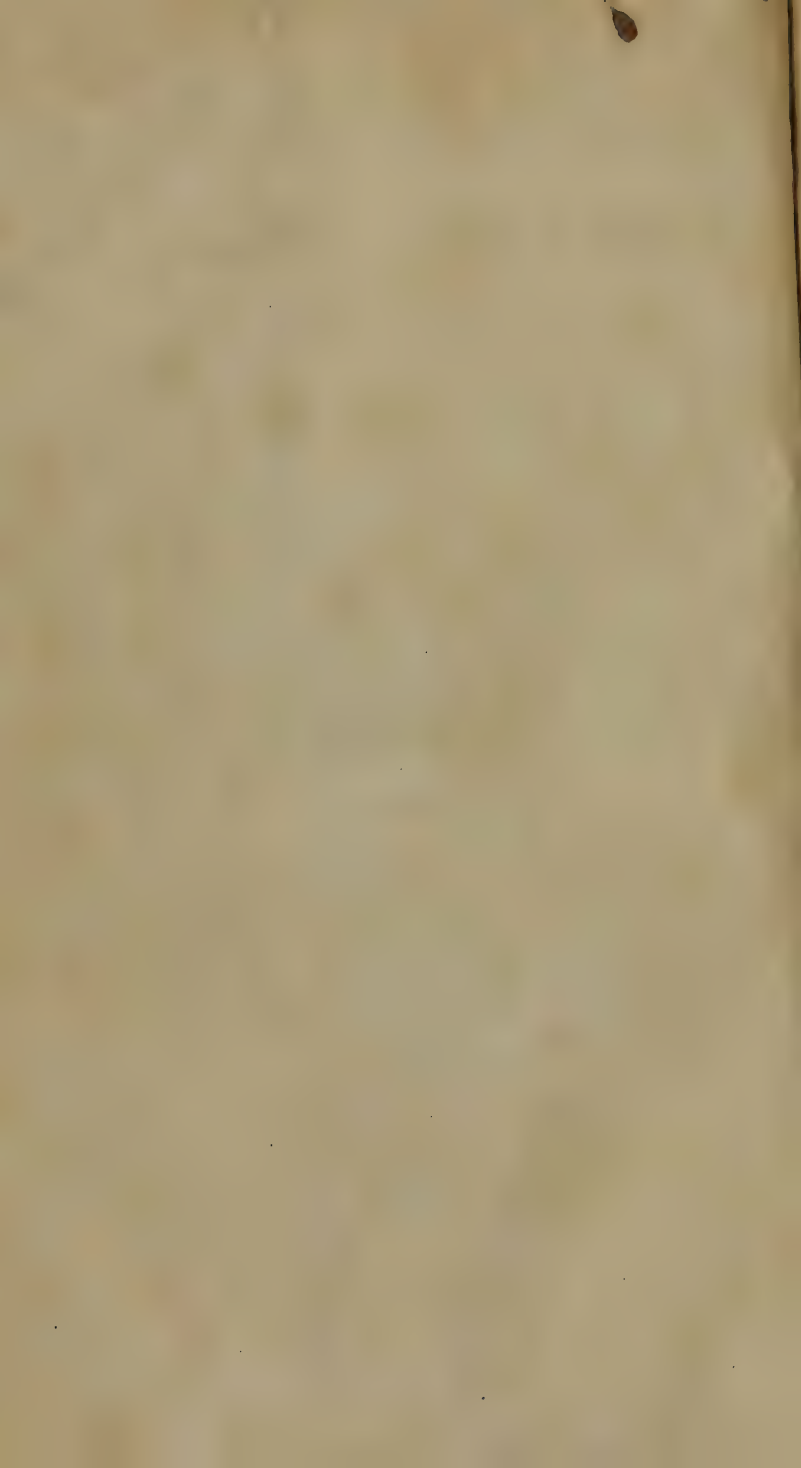
FOR THE USE OF HIS PUPILS.

PART SECOND.

PHILADELPHIA:

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1822.



MINUTES,

&c. &c.

OF SOME IMPORTANT PRINCIPLES, SUPPOSED TO CONSIST OF
PONDERABLE, UNITED WITH IMPONDERABLE MATTER.

It appears from the phenomena of calorific repulsion, that ponderable matter, by combining with caloric, first expands, next melts, and finally passes into that elastic state of fluidity, in which the repulsive power so far predominates over the attractive, that the particles recede from each other as far as external pressure will permit. When an aëriform fluid, thus produced, is condensible per se, it is called a vapour; when per se incondensable, it is called a gas.

The chemistry of gaseous substances, has been called Pneumatic Chemistry.

OF THE ORIGIN OF PNEUMATIC CHEMISTRY.

All gases were considered as common air, variously modified by impurities, until Dr. Black's discovery of carbonic acid gas. Priestley, incited by this, to obtain air from other bodies, discovered oxygen gas, nitrogen gas, nitrous air, or nitric oxide, and various other aëriform substances. Cavendish, about the same time, distinguished hydrogen gas as a peculiar kind of air.

ON THE MODE OF COLLECTING, AND PRESERVING GASES IN
THE PNEUMATO-CHEMICAL APPARATUS.

PNEUMATIC CISTERN CONTAINING WATER EXPLAINED : ALSO A PNEUMATIC CISTERN CONTAINING MERCURY.

Vessels are filled with water, or mercury, in a pneumatic cistern, and inverted as in the Toricellian experiment; then placed on a shelf, or part of the cistern, purposely

kept, just below the surface of the water or mercury. Any gas emitted under the mouth of a vessel, so filled and situated, rises and displaces the contained fluid.

OXYGEN GAS.

This gas forms one fifth of the atmosphere in bulk. Its ponderable base pervades the creation, as a constituent of water in the ratio of eight parts in nine. It is a principal, and universal constituent of animal and vegetable matter. Its combinations with metals, and various other combustibles, are of the highest importance in the arts. It was called oxygen, under the erroneous impression of its being the sole acidifying principle, from the Greek *οξυς*, acid *γενεσθαι*, to generate.

ON THE MEANS OF PROCURING OXYGEN GAS.

Manganese yields it, when exposed to a bright red heat in an iron bottle. Red lead, or nitre, may be used for the same purpose in like manner. There are various other means of obtaining oxygen gas. It is obtained purest from the chlorate of potash.

PROPERTIES OF OXYGEN GAS.

It is insipid, inodorous, incondensable per se, colourless, and transparent. It is but slightly absorbed by water: does not differ from common air in appearance, but is somewhat heavier, and it supports life and combustion, more actively. Under a bell glass filled with oxygen gas, an animal lives, and a candle burns, thrice as long as, similarly situated, with the same quantity of air.

Oxygen gas is supposed to consist of oxygen, a simple or elementary substance, rendered aëriform by caloric.

PROPERTIES OF OXYGEN GAS, ILLUSTRATED BY EXPERIMENTS.

Combustion of iron wire, charcoal, sulphur, and phosphorus, exhibited in large glass vessels of appropriate construction. Homberg's pyrophorus, being poured into it, flashes like gunpowder. Flame of caoutchouc, and other smoky flames, are rendered bright by surrounding them

with this gas. An intense heat is produced in a lamp flame, urged by a jet of oxygen gas.

OF CHLORINE GAS.

As a gas, this substance exists only by artificial means; but its ponderable base, as forming three-fifths of marine salt, constitutes nearly one-fiftieth of the matter in the ocean; and is widely disseminated throughout the land, as well as the sea. It is also an ingredient in some of the most active agents, used in chemistry, or medicine. It was discovered by Scheele, and called by him deplogisticated marine acid—afterwards oxymuriatic acid, by Lavoisier, and chemists generally, who adopted his nomenclature. Its present name was given by Sir H. Davy, from *χλωρος*, green—because its colour is greenish.

MEANS OF OBTAINING CHLORINE.

It is obtained by heating manganese, or red lead, and muriatic acid, in a glass or a leaden vessel: or common salt, diluted sulphuric acid, and manganese.*

PROPERTIES OF CHLORINE GAS.

When pure and dry, it is a permanent gas, of a greenish yellow colour. When moist, it condenses at 40 degrees of Fahrenheit. It is in weight to common air, as two and a half to one, nearly. Even when disseminated in the air in very small particles, its effects upon the organs of smell and respiration are intolerable; and it is in the highest degree deleterious, when inhaled alone.

That species of chemical action, which is attended by the phenomena of combustion, is supported by this gas with great energy. It has a curious property, first noticed by me, I believe, of exciting the sensation of warmth, though a thermometer, immersed in it, does not indicate that its temperature is greater than that of the adjoining medium. Probably it acts on the matter insensibly per-

* The proportions are, three parts manganese, four parts salt, four parts sulphuric acid, and four parts water.

spired.* Chlorine is absorbed by water, and in the solution acts powerfully on metals. It appears to be the only solvent of gold. Chlorine and silver, exercise a more energetic affinity for each other, than for any other substances. Hence, they are reciprocally, the best tests. The compounds of chlorine with mercury, so useful in medicine, will be treated of, when on the subject of that metal. When the aqueous solution of chlorine, is exposed to the solar rays, it forms muriatic acid, with the hydrogen of the water, while the oxygen escapes. It bleaches, by liberating the oxygen of water, and thus enabling it to act on the colouring matter.

Chlorine gas was considered as a compound of muriatic acid and oxygen, and called oxymuriatic acid, till within about fifteen years. It is now, generally deemed an elementary substance, and rendered gaseous by caloric.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF CHLORINE.

Combustion exhibited, of metals in leaf, and in powder—of mercury in vapour—of phosphorus, by an appropriate contrivance. Water tintured by litmus, rendered colourless, by merely falling through this gas. To two large vessels of clear water, soluble compounds of chlorine and silver are severally added—no change ensues, till the contents of both vessels are mingled in the third vessel, when a white cloud appears.

OF IODINE.

This substance, which has only been detected in certain plants, or their ashes, derives importance from its analogy with chlorine and oxygen, especially the former. It was named Iodine, from *ιοειδης*, violet coloured.

OF THE MEANS OF OBTAINING IODINE.

It is obtained from the mother waters, of carbonate of soda manufactured from kelp. After all the soda, in a

* If the difficulty of applying it could be surmounted, as in the case of sulphurous acid, it might possibly check the chill in ague.

lixivium of kelp, has been crystallized, the residuum is concentrated, and distilled with sulphuric acid, in a retort: the iodine passes over, and condenses in shining crystals, of an intense purple, or a black colour.

OF THE PROPERTIES OF IODINE.

When solid, it is of a bluish black colour—friable—acid—and almost insoluble. It transiently stains the skin yellow. It fuses at 225° F.—volatilizes at 350° in a most beautiful violet vapour. It is considered as an element.

Iodine is incombustible either in oxygen, or atmospheric air; but forms acids severally with oxygen, hydrogen, and chlorine, called oxiodic—chloriodic—hydriodic acids.* In its habitudes with the Voltaic pile, it is more electro-negative than any other matter, excepting oxygen, chlorine, and probably fluorine. With starch or fecula, it produces an intense blue colour; so that these substances, are reciprocally tests for each other.

EXPERIMENTAL ILLUSTRATIONS.

A glass sphere, containing iodine, on being warmed, appears filled with a violet coloured vapour.

To a large glass vessel, containing some boiled starch diffused in water, a small quantity of iodine being added, the fluid becomes intensely blue.

OF THE NOMENCLATURE OF THE COMPOUNDS OF CHLORINE, OXYGEN, AND IODINE.

Agreeably to the nomenclature proposed by the celebrated Lavoisier, and his coadjutors, and generally adopted by chemists; when oxygen, in combining, does not acidify, the resulting combinations are called oxides. Hence, by analogy, the compounds of chlorine with other substances, when not acidified by it, are called chlorides; those of iodine, iodides.

* The oxodic acid is also called iodic acid.

OF NITROGEN GAS, OR AZOTE.

Nitrogen gas forms nearly four-fifths of the atmosphere. Its ponderable base is a principal element, in animal substances. In vegetables, it is only occasionally found. It was called azote, from the Greek *αζωη*, life, and *α*, privative of; but as other gases were found no less worthy of this distinction, the name of nitrogen was given it, because it produces nitric acid.

MEANS OF OBTAINING NITROGEN GAS.

It may be procured by any substance which will, in a close vessel, abstract oxygen from the included portion of the atmosphere;—as, for instance,—by the combustion of phosphorus:—by iron filings and sulphur moistened:—by nitrous gas.

OF THE PROPERTIES OR CHARACTERISTICS OF NITROGEN GAS.

As a gas, it is distinguished by a comparative want of properties. It is lighter than oxygen gas or atmospheric air. It does not support life or combustion, but is not injurious to life. It is incondensable per se, and seems to carry its caloric into combination, in many instances, being a constituent of a majority of the most explosive compounds. It is apparently an inert constituent, of the atmosphere.

Nitrogen has been suspected, by some chemists, of being a compound substance, but is generally considered as an element. Its compounds with oxygen, hydrogen, chlorine, carbon, &c. will be treated of hereafter.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF NITROGEN.

After phosphorus is burnt out in a close vessel, the residual air is transferred to a convenient bottle. A candle flame introduced into the bottle, is extinguished.

ATMOSPHERIC AIR,

Is a mixture (not a chemical compound) of oxygen gas, and nitrogen gas, with some moisture, and carbonic acid

The properties of this compound gas, are such as might be anticipated from those of its constituents. Its active qualities are those of oxygen, but enfeebled by dilution with the other inert ingredients.

MEANS OF ASCERTAINING THE QUANTITY OF OXYGEN, OR OTHER GASEOUS MIXTURES, IN THE AIR.

EUDIOMETRY.

DIFFERENT EUDIOMETERS EXHIBITED.

Simple graduated tube. Hope's Eudiometer. Henry's modification of Hope's Eudiometer. Volta's Eudiometer. Various eudiometrical instruments contrived by me.

OF HYDROGEN GAS.

In its gaseous state, it is the principal constituent of all ordinary flame. Its ponderable base, combined or associated with oxygen, or carbon, or both, is found in water, and all vegetable and animal substances. It derives its name from *υδωγ*, water, and *γεννωμαι*, to produce.

MEANS OF PROCURING HYDROGEN GAS.

It may be obtained by the reaction of diluted sulphuric, or muriatic acid, with zinc, or iron; or of steam with iron turnings, made red hot in a gun barrel:—also, by means of potassium. It may be evolved from water by galvanic agency, and is then purest.

ON THE PROPERTIES OF HYDROGEN GAS.

It is the lightest of all known substances. A cubic inch, weighs only about a fiftieth of a grain. It is about 200,000 times lighter than mercury, and 300,000 times lighter than platina. In its ordinary state, it smells unpleasantly. When pure, it is alleged to be without odour. It is perfectly incondensable per se. Its capacity for heat is very high. It does not support life, but is not very injurious to it. In consequence of its levity, it escapes rapidly from an open vessel, unless inverted. It is the most inflammable of all substances, yet extinguishes a taper when immersed in it. A jet of it ignited, appears like

a candle flame, feebly luminous: and if surrounded by a glass tube, produces a remarkable sound. Subjected to the electric spark, when mixed with oxygen or atmospheric air, it explodes. The oxygen may be esteemed equal to one-third of the deficit caused by the explosion; hence, by this process, air may be analysed. The ponderable base of hydrogen gas forms water, with oxygen; muriatic acid, with chlorine; hydriodic acid, with iodine; ammonia, with nitrogen: and Prussic acid, with cyanogen. It combines also with carbon—with sulphur—and with phosphorus. When pure, its flame is but feebly luminous.

Hydrogen gas is considered as an elementary substance, so attractive of caloric, as that it cannot be separated from it.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF HYDROGEN GAS.

Its evolution from a phial, (with a capillary tube well fitted to the neck) exhibited; and the jet, ignited. A glass retort, with diluted acid and zinc, employed, to show the extrication of this gas, and mode of catching it in bell glasses over the cistern. Self-regulating reservoir of hydrogen gas in glass exhibited,—likewise a self-regulating reservoir in wood. A phial, filled with gas, inverted; and, by means of it, a candle extinguished, and lighted again. Hydrogen ignited by an electrophorus: by galvanic ignition—also exploded with atmospheric air, and with oxygen gas, by a taper,—a calorimotor,—and by electricity. A glass balloon being balanced on a scale beam, hydrogen is made to displace the air. The balloon rises, because the hydrogen is lighter than air.

EXPERIMENTS WITH THE COMPOUND BLOWPIPE.—PYROTECHINY BY MEANS OF HYDROGEN.

WATER

Is produced by the combustion of hydrogen gas, with oxygen gas. It may be decomposed by passing it in steam, over iron ignited, in a gun-barrel: by the aid of acids: by electricity: by galvanism: by the alkaline me-

tals: by sulphurets, phosphurets, and vegetable leaves. Water is vaporizable by heat, and evaporable by means of its attraction to the air. A certain proportion of moisture, in the air, is necessary to health, and comfort.

MEANS OF DETECTING, OR MEASURING HUMIDITY IN THE AIR.

OF HYGROMETERS.

ON HYGROMETERS BY EVAPORATION. ON THE HYGROMETER BY MEANS OF AN ORGANIC SENSIBILITY TO MOISTURE, IN THE BEARD OF THE WILD OAT.

ON SOME PECULIAR AND IMPORTANT AGENCIES, OR CHARACTERISTICS, OF WATER.

Water is necessary to some crystals.—It appears necessary to acidity—to alkalinity—and to galvanic processes. The powers of water, as a solvent, are peculiarly extensive, and are increased by heat and pressure. It seems to be a substance, *sui generis*, isolated from oxides, acids, and alkalies. It unites with, and becomes solid in, the earths and alkalies; and produces heat during combination with them. The compounds resulting, are called hydrates.

EXPERIMENTAL ILLUSTRATIONS OF THE AGENCY OF WATER.

Tartaric acid, and bicarbonated alkali, pulverized, and mixed. The addition of water produces effervescence. Nitrate of copper rolled up in tin foil has no action till moistened—ignition then ensues. Sulphuric acid added to zinc in powder. The addition of water produces a violent action. Heat produced by caustic earths, or alkalies with water.

EXPERIMENTAL DEMONSTRATION, OF THE COMPOSITION OF WATER.

Water, recomposed by combustion of hydrogen, emitted in a jet within a large glass vessel. Decomposed by a galvanic apparatus, and its gaseous elements evolved:—these are exploded by the spark, and reduced again to the aqueous form.—Decomposed by sulphuret, and phosphuret of lime, and potassium.

ON THE THEORIES OF COMBUSTION.

Stahl supposed one universal principle of inflammability to exist, which he called phlogiston. He inferred, that all substances in burning, give out phlogiston. The fallacy of this doctrine is evident, since metals become obviously heavier in burning.—According to the advocates of the phlogistic theory, nitrogen was confounded with carbonic acid, and carbon with hydrogen. Sulphuric, and phosphoric acids, and metallic oxides, were severally supposed to be ingredients, in the sulphur, the phosphorus, or the metals, producing them : thus the compounds were assumed to be lighter, and to be contained by one of their constituents ! Lavoisier's theory was correct, in suggesting, that in all ordinary cases of combustion, oxygen is absorbed. It was erroneous, in not providing for exceptions, as, when metals burn in sulphur, or in chlorine.

Combustion, according to common sense, is an intense state of corpuscular reaction, accompanied by an evolution of heat and light.

It is a general law of nature, that the capacities for caloric, of compounds, are sometimes greater, sometimes less, than that of their constituents. Hence chemical combination, is sometimes productive of heat, sometimes of cold.

There is a mysterious, and reciprocal dependency, between chemical reaction, and galvanism electricity and magnetism, which cannot yet be explained.

The heat of combustion is principally due to the gaseous agent; the light to what is called the combustible. The idea of a class of supporters of combustion, and of combustibles, has no other foundation, than that certain substances are more frequently agents in it, and therefore called supporters. Thus, hydrogen will only produce fire, with oxygen, and chlorine;—sulphur with metals;—and carbon, with oxygen; but as oxygen or chlorine, will burn with a great variety of substances, they are called supporters of combustion, and the substances with which they combine, during combustion, are called combustibles.

Iodine is classed among the supporters also, because it combines with almost all the substances with which they unite, and forms analogous compounds. Iodine is not gaseous, however, and, upon the whole, is as analogous to sulphur as to chlorine.—The propriety is questionable, of taking it into the class of supporters, and excluding sulphur.

Sulphur is intermediate, in its habitudes, between phosphorus and iodine. The habitudes of selenium, a newly discovered substance, seem to lie between the metals and sulphur. Carbon—boron—and silicon, are at the opposite extreme of the gradation. The terms supporter of combustion, and combustible, are evidently commutable terms; since a jet of oxygen, fired in hydrogen, is productive of a flame similar to the inflamed jet of hydrogen in oxygen. If we breathed in an atmosphere of hydrogen gas, oxygen gas would be called an inflammable air.

THEORY OF VOLUMES.

It has been advanced by Gay Lussac, that substances, when aëriform, unite in volumes which are equal; or that the larger volume, is double, triple, or quadruple, of the other. The same language is applied by him, to numbers expressing measures of volume, as is applied by Dalton, Wollaston, Davy, and others, to numbers representing equivalent weights. This doctrine is well supported by facts. It has been adopted by Berzelius, and other eminent chemists. It is not inconsistent with the atomic theory, if the number of atoms in equal volumes be as 1 to 1, 1 to 2, 1 to 3, 1 to 4, &c.; so that the least number of atoms in any one combining volume, will divide all the larger numbers in other combining volumes, without a fraction. The doctrine of volumes, is extended by inference to all bodies, under the idea, that all are susceptible of the aëriform state.

Instances supporting the doctrine of volumes:—

Water consists of	1 volume of	Oxygen and	2 Hydrogen gas.
Ammonia	1	Nitrogen	3 Hydrogen.
Carbonic acid	1	Oxygen	2 Carbonous } oxide. }
Sulphuric acid	1	Oxygen	2 Sulphurous acid.

Muriatic acid	1	volume of	Chlorine	1	Hydrogen.
Muriate of ammonia	1		Ammonia	1	Muriatic acid
Sub carbonate of ammonia.	}	1	Ammonia	1	Carbonic acid.
Bicarbonate of ammonia.					
	}	1	Ammonia	2	Carbonic acid.
Nitrous gas	1		Nitrogen	1	Oxygen.

ON THE ALKALIES.

Alkali is a word supposed to be derived from the Arabic. Until of late, only three alkalies were known:—they are divided into the fixed alkalies, and the volatile alkali. Potash and soda, are the fixed alkalies. The volatile alkali is called ammonia. A new mineral fixed alkali has been discovered lately, and named Lithia. It is procured from a stone called Petalite. Hence, its name from the Greek *λίθος*, a stone. Alkalies have also been recently detected among vegetable principles; Morphia, the active principle of opium; and Stricnia, the active principle of nux vomica, are ascertained to be alkaline.

OF POTASH.

MEANS OF OBTAINING POTASH.

It is obtained by the lixiviation of the ashes of inland plants, especially wood. The ley, thus procured, boiled down, forms potashes of commerce. Potashes, ignited, lixiviated, and evaporated to dryness, form pearlash. Pearlash, dissolved, boiled with quicklime, filtered, and boiled down to the consistence of moist sugar, redissolved in alcohol, and boiled down gradually; and lastly, fused at a red heat in a silver vessel, yields the potash of chemists. Evaporation being stopped, as soon as the alcohol has escaped, crystals are obtained. After fusion at a red heat, it contains about 20 parts of water, of which it cannot be deprived, per se, by heat. It is therefore called a hydrate.

Soda is obtained from sea salt:—from sulphate of soda:—or from the ashes of certain plants which grow on the sea shore, as potash is, by the incineration of those which grow inland.

Soda is purified, and procured in the state of hydrate, or in crystals, by the process, above described, for its kindred alkali.

PROPERTIES OF POTASH AND SODA.

Potash and soda, in common with other alkalies, have a peculiar alkaline taste: they render tincture of turmeric, brown; syrup of violets, green; and alkanet, blue. Colours, changed by acids, are restored by them. They are the opposites of, and antidotes to acids, forming with them compounds, neither acid nor alkaline. They are incorrectly said to render vegetable blues green, as if this were universally true. Alkanet is made blue by them, while neither is litmus, nor indigo, made green.

Potash is much more deliquescent than soda; though its salts are less soluble. Both cauterize the flesh. Potash is most active. Lapis infernalis, or common caustic, is an impure hydrate of this alkali.

Potash is distinguished from soda, by forming a less soluble salt with tartaric acid, and giving a precipitate with muriate of platina. Subjected to galvanic action, both alkalies are decomposed into oxygen gas, and metallic bases, called potassium and sodium.

OF SOAP.

OF SOFT SOAP, OR SOAP OF POTASH, AND HARD SOAP, OR SOAP OF SODA

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF POTASH AND SODA.

Infusions of litmus, (reddened by an acid,)—of alkanet—of tumeric—and red sanders, are poured into large glasses. By a drop or two of potash, the alkanet becomes blue—the turmeric brown—the red sanders, claret colour—while the litmus regains its blue. To strong solutions of potash and soda, or their carbonates, a strong solution of tartaric acid being added in excess, the potash only yields crystals. Into different salts of the two alkalies in solution, muriate of platina is poured. A light yellowish precipitate, distinguishes the potash.

OF LITHIA, THE NEWLY DISCOVERED MINERAL ALKALI.

Pure lithia is less soluble than soda or potash, in water or alcohol. Its carbonate is less soluble in water. Its muriate is soluble in alcohol, and its phosphate insoluble in water.

OF POTASSIUM.

It is named, from the alkali which yields it.

MEANS OF OBTAINING POTASSIUM.

It was discovered by Sir H. Davy, by means of the Voltaic Pile, and of course may be thus procured; but the following method, contrived by Gay Lussac, enables the chemist to obtain it in larger quantities. A luted gun-barrel is filled with iron wire, or turnings, and ignited in a blast furnace, as highly as possible. Hydrate of potash is passed in at one end, so as to fuse and run over the iron, which arrests its oxygen. The potassium meanwhile volatilizes, and condenses at the other end of the barrel, just beyond where it is red hot.*

PROPERTIES OF POTASSIUM.

It appears, and cuts like lead, only softer; yet it is so light as to swim in water. It fuses at 150° F. It decomposes water, regenerating potash, and evolving inflamed potassuretted hydrogen, upon the water, and even upon ice. Its avidity for oxygen is pre-eminently great. When heated in oxygen gas, in excess, an oxide is formed containing double the quantity of oxygen found in potash. If hydrate of potash be applied to a thick plate of iron, in a state of combustion, the rosy flame of potassuretted hydrogen demonstrates, that a decomposition ensues.

* There is great uncertainty in this process, from the difficulty of getting the luting to stand the requisite heat, without which, the gun-barrel soon burns. I have substituted for the luting, a very thick cylinder of iron, which renders the process certain.

OF SODIUM.

The analogy between this metal and potassium, is quite as great, as between potash and soda.

MEANS OF OBTAINING SODIUM.

Sodium is obtained by the same process as potassium. It is less energetic, than potassium, in its action. It does not fuse so easily, as it requires 200° F. It decomposes water, evolving hydrogen, but without inflammation.

EXPERIMENTAL ILLUSTRATIONS.

The inflammation of potassium upon water, and ice exhibited—also, the decomposition of potash by a burning iron.

OF AMMONIA, OR THE VOLATILE ALKALI.

It is named from the salt which yields it.

MEANS OF OBTAINING AMMONIA.

Sal ammoniac, in powder, being mixed with powdered quicklime, or caustic fixed alkali, ammonia is evolved in the state of a gas, which may be collected over mercury. Heat is requisite to complete the process.

PROPERTIES OF AMMONIA.

Ammonia acts like an alkali, upon the organs of taste, upon vegetable colours, and in neutralizing acidity. To the smell it is agreeably stimulating, when very much diluted with the air. In any considerable proportion, it is intolerable to the eyes, and organs of respiration. It enlarges, and then extinguishes, a candle flame; yet explodes with oxygen or chlorine. Its weight, to common air, is as 3 to 5—100 cubic inches weigh 18 grs. Water absorbs it with surprising velocity; and will hold from 450, to 670 times its bulk. Ice melts in ammonia, quicker than in a fire. Heat either decomposes or volatilizes all ammoniacal compounds; and either of the fixed alkalies, or of the three more powerful alkaline earths, disengage it.

ON THE COMPOSITION OF AMMONIA.

In a cavity, made in a bit of muriate of ammonia, a moistened globule of mercury is supported, in communication with one of the poles of a Voltaic pile. The mercury is made to communicate with the other pole. The metal swells rapidly, and assumes all the characteristics of an amalgam. It would be anomalous for an amalgam, to arise from a union of mercury with any substance not metallic. It may therefore be inferred, that ammonia is a gaseous alloy of hydrogen and nitrogen—that these, if obtained in the solid state, would be metalloidal in their characteristics.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF AMMONIA.

Sal ammoniac and quicklime, being powdered and mixed in small glasses—pungent fumes are emitted. The same mixture contained in Florence flasks, being exposed to a chafing dish of coals, the ammonia is extricated, and collected in bell glasses, over mercury. The introduction of a few drops of water, causes the gas to disappear. Ice, in the same way introduced, is liquefied, and causes a like result. Water, tinctured by turmeric, alkanet, &c., changed as by other alkalies.

Evolution of gas shown, by means of potash and an ammoniacal salt introduced into a glass vessel over mercury.

Other illustrations deferred, until muriatic and carbonic acids are treated of.

OF EARTHS.

The substances classed under this head, are the principal ingredients in the congeries, called earth, in common language; and which, until lately, was considered one of the four only elements of the creation. The earth of flints, or of sand, is one of these substances. It is exhibited, in purity, in rock crystal, and is called silex, or silica.

The earth, to which clay owes its plastic property, is

named alumine, by chemists; because it is obtained in purity from alum. Next to silex, it is the most abundant earthy material in the globe.

Lime follows next—afterwards magnesia—and then, in far less proportion, certain other substances almost unknown to men in general: and which, but for chemical skill, had escaped human observation. These are the barytes, strontites, glucine, zircon, yttria, and thorina, of chemists.

The earths are divided into earths proper, and alkaline earths.

OF THE ALKALINE EARTHS.

The alkaline earths are, barytes, strontites, lime, and magnesia.

OF THE PROPERTIES OF THE ALKALINE EARTHS.

They are thus designated, because they are alkaline in taste and in their effects on vegetable colours; and because, like the alkalies, they lose their causticity, by a union with carbonic acid. All are more or less soluble; but magnesia the least so; barytes and strontites, form glass with silex; and with water, hydrates, indecomposable by heat. The order in which they are alkaline, beginning with that which is most so, is as follows: barytes, strontites, lime, and magnesia.

COMPOSITION OF THE EARTHS.

The alkaline earths hold a middle place between the old metallic oxides, and those of potassium and sodium. The other earths are generally inferred to be metallic oxides. To me, it seems more likely, that they form a class of bodies intermediate, between carbon and boron, and the metalloids; or passing from the one into the other. This view of the analogy between carbon, and the bases of alumine and silex, is very much strengthened by the discovery in these, of a property heretofore supposed peculiar to carbon, of forming steel by combining with iron.

OF BARYTES.

This earth was named from the Greek *βαρυς*, (heavy,)

because the minerals containing it are peculiarly heavy, when compared with other earthy substances.

OF THE MEANS OF OBTAINING BARYTES.

Carbonate of barytes, or the sulphuret (obtained by igniting sulphate of barytes intensely with charcoal) is to be exposed to the action of nitric acid, in a quantity sufficient to saturate it. The solution must be filtered and evaporated, and then deprived of water by an intense heat, in a platina, or porcelain crucible.

Like the carbonates of potash and soda, those of barytes and strontites, cannot be decomposed per se by heat. The addition of carbonaceous matter, enables us to decompose them, as it changes the carbonic acid to gaseous oxide of carbon, which has no affinity to the earths, and therefore escapes.

OF THE PROPERTIES OF BARYTES.

It is acrid—slakes like lime, and is more caustic and more soluble in water. It is gray at first, but absorbs water and becomes white. Its aqueous solution is rendered milky by carbonic acid, and by combining with the same principle, becomes covered with a pellicle of carbonate when exposed to the atmosphere. Barytes crystallizes, on cooling, from its solution, in boiling water. Ignited intensely, and exposed to a current of oxygen gas, it absorbs the oxygen and passes to the state of deutoxide. Its solutions are the best tests for sulphuric acid, and reciprocally sulphuric acid is the best test for barytes. This earth is poisonous.

EXPERIMENTAL ILLUSTRATIONS.

Barytes exhibited, both dry and in crystals. Barytic water rendered milky by the carbonic acid of the breath, passed through it by means of a tube. Solutions of barytes, or of sulphuric acid, introduced into distinct vessels of pure water, have no effect; but portions mingled, in the same vessel, produce a cloud. Water, coloured by alkanet, turmeric, &c. changed by barytes, as in the case of the alkalies.

STRONTITES.

It is as analogous to barytes, as potash to soda. In its properties and composition, it is distinguished from barytes, by its solutions colouring flame red—by its crystallization—by its being more soluble in boiling water, and less so in cold.

EXPERIMENTAL ILLUSTRATIONS.

Turmeric—alkanet—and red sanders changed by the strontitic water, as by alkalies.

Red colour of inflamed alcohol, containing strontites, shown.

ON LIME.

OF THE MEANS OF OBTAINING LIME.

This earth may be procured from oyster shells, or white marble, by calcination.

OF THE PROPERTIES OF LIME.

Lime is less alkaline, than the preceding earths. Its carbonate does not retain its water and acid, when heated intensely.

Quick-lime is pure lime, or limestone deprived of its water and acid. When moistened it slakes, that is, heats and falls into powder. The earth absorbs and causes the consolidation of the moisture, which is consequently abandoned by the caloric to which water is indebted for its fluidity.*

Water takes up about $\frac{1}{700}$ of its weight, of this earth, forming lime water. On this, a pellicle forms, as in the case of barytes, soon after exposure to the air, by the union of the lime with the carbonic acid, which always exists in the atmosphere. Though lime is precipitated by carbonic acid, in the state of carbonate, water, impregnated with this acid, dissolves the carbonate—hence limestone water. Lime was first fused by me. Oxalic acid is the best test for lime. ✱

* See minutes, page 10, 1st part

*By heating yellowish air, to which
lime has been added, it is made*

EXPERIMENTAL ILLUSTRATIONS.

A glass of lime water, is not made turbid by air from a bellows, but becomes so on blowing through it with the mouth. Carbonic acid in bells, and bottles:—absorption of it, shown. Lime precipitated from solutions of its muriate or nitrate, by sulphuric, or oxalic acids.

OF MAGNESIA.

MEANS OF OBTAINING MAGNESIA.

This earth may be precipitated by potash or soda from a solution of Epsom salts.

OF THE PROPERTIES OF MAGNESIA.

Magnesia is nearly insoluble in pure water, but dissolves to a considerable extent in water, containing carbonic acid, forming a bicarbonate, or soluble magnesia. Affusion of concentrated sulphuric acid, on calcined magnesia, produces great heat and even ignition.

Magnesia is distinguished from the other alkaline earths, not only by being less energetic, in its affinities and alkaline properties, but by the solubility of its sulphate.

Lime and magnesia are among the most fixed, and refractory substances in nature; and were deemed infusible, until I operated upon them, with the compound blowpipe.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF MAGNESIA.

Its precipitation from a solution of Epsom salts exhibited. Infusions of alkanet, and of turmeric, &c. exposed to magnesia.

OF SILEX.

MEANS OF OBTAINING SILEX.

Quartz being powdered, and fused with double the weight of pearlash, and lixiviated; a liquor silicuni results: from which, when poured into an acid, the earth separates. Thus obtained, it is slightly contaminated by potash. Fluoric acid, by its action on glass, or flints,

takes up silex, or its base, and, according to Brande, deposits it in a state of sub-fluate, on meeting with water.

OF THE PROPERTIES OF SILEX.

Pure silex is white—tasteless—inodorous—and insoluble. It was deemed infusible, until fused by me in 1802. It does not cohere when wetted. In powder, it is acted on by alkaline solutions. Glass consists of silex, united with about one half its weight of fixed alkali. The proportions are those, of the liquor silicum inverted.

EXPERIMENTAL ILLUSTRATIONS.

Silicate of potash—a soluble glass—exhibited—also the solution of it, called liquor silicum, which is made to precipitate its silex, by means of an acid.

OF GLASS.

OF ANNEALING. OF PRINCE RUPERT'S DROPS.

OF ALUMINE, OR THE PURE EARTH OF ALUM.

OF THE MEANS OF OBTAINING ALUMINE.

It is found pure in the gems called by jewellers oriental, and classed by Brogniart under the head of Corindon Telesic. The ruby, sapphire, amethyst, and topaz, of the most beautiful kinds, are thus designated. They have the highest specific gravity of stony minerals, and are only inferior to the diamond in hardness. Differing from each other, only in colour, they yield by analysis little else than pure alumine. There are other jewels of the same name and colour, which ought not to be confounded with those here spoken of.

Alumine is obtained sufficiently pure, by potash, from a solution of alum.

OF THE PROPERTIES OF ALUMINE.

It is inodorous, insipid, and infusible in the furnace. It is plastic when moistened—soluble in alkalies and acids—and combines with colouring matters, forming the precipitates called lakes. It is the only earth which was

fused before the compound blowpipe was invented. Its property of contracting and hardening by heat, was treated of, when on the subject of Wedgewood's pyrometer.*

EXPERIMENTAL ILLUSTRATIONS.

A solution of alum precipitated by an alkali.

OF ZIRCON, GLUCINE, YTTRIA, THORINA.

As they are objects merely of scientific curiosity, attention to their details would be injudicious, until other knowledge be acquired.

OF ACIDITY.

Acidity was originally synonymous with sourness. Substances now called acids, are not, in every instance, sour. Acids generally make vegetable blues red; but not invariably. Sulphurous acid whitens litmus, and indigo is not reddened by any acid. Acids always neutralize alkalies, and restore colours destroyed by them. Acids do not combine with acids—nor alkalies with alkalies,—but acids and alkalies unite energetically with each other. Acids are generally soluble in water. Silex furnishes an exception. The idea of a universal acid principle, commenced with Paracelsus,—was supported by Beecher and Stahl, and afterwards by Lavoisier;—but it was questioned, by Berthollet.

The existence of a common cause, not only of acidity, but of alkalinity, still, to me, appears probable.

It will be shown hereafter, that if any two light bodies, be electrified, either by glass or resin, they will separate; but that if one, be electrified by glass, and the other by resin, they will attract each other.

The cause of galvanic phenomena has been supposed by many great philosophers, to be the same as that of electricity produced by glass, or resin; but modified by some unknown cause, so as to act between atoms, instead of masses.

The pole, or end of a galvanic or Voltaic series, terminating with the most oxidable metal, has been found to

* Minutes, 1st part, page 11.

show a very feeble electrical excitement, of the same kind as that produced by glass;—while the other termination of the galvanic series, displays the opposite excitement of resin.

As far as a very extensive experience has gone, it would seem, that, of any two substances in nature, simultaneously exposed to wires, severally proceeding from the different poles of a galvanic series,—one will go to the positive, the other to the negative pole. Atoms are inferred to be in electrical states, different from the poles to which they are severally attracted; and are said to be electro-negative, when attracted by the positive pole—and electro-positive, when attracted by the negative pole. Oxygen is conceived to be more invariably attracted by the positive pole, than any other substance. Next to oxygen, chlorine is most electro-negative:—and iodine next to chlorine. Other substances, as for instance, metalloids and metals,—also hydrogen, carbon, sulphur, and phosphorus, are comparatively electro-positive. Substances, of the two opposite classes, in combining with each other, constitute particles, which are either electro-positive, or electro-negative, accordingly as the different energies of their ingredients preponderate. Thus, in alkalies, consisting of oxygen united with metalloids, the electro-negative character of the metalloids is predominant; but the reverse is true, of acids consisting of the same electro-negative principle oxygen, in combination either with sulphur, nitrogen, phosphorus, carbon, boron, or other substances, of an electro-positive character.

At a mean point, between the extremes, at which oxygen and the alkaline metalloids are placed, there are substances whose relation to the pile is equivocal or wavering; and it should be understood, that this relation is always comparative. Chlorine is electro-positive with oxygen, and electro-negative with every other body. Iodine is electro-positive, either with chlorine or oxygen, and with other substances, electro-negative.

I avail myself of the language, which has arisen from the hypothesis by which these polarities are ascribed to electricity, though I do not think their existence thus adequately accounted for.

I suspect, that alkalinity and acidity, and these galvanic polarities, have a common cause, perhaps in some appropriate combinations of the imponderable, but material, causes of heat, light, and electricity. To other combinations of these imponderable principles, the sweetness of sugar, the pungency of mustard, or of pepper, and the activity of certain vegetable poisons, may be due. It is known that in morphia, and strychnia, and in certain vegetable acids, the acid and alkaline properties are adventitious, being attached to elements, which exist in other compounds, without inducing acidity, or alkalinity.

ON THE NOMENCLATURE OF ACIDS, AND THEIR SALTS.

Where substances form, by a union with oxygen, two oxides, or two acids—one containing a larger—the other a lesser proportion of it;—the acid, or oxide, having the lesser proportion, is distinguished by the name of the substance oxygenated, and a termination in *ous*:—that containing the larger proportion of oxygen is designated in the same way, substituting *ic* for *ous*—as sulphurous acid, and sulphuric acid—nitrous and nitric oxide, or acid—carbonic acid, carbonous oxide.* Acids, of which the names terminate in *ous*, have their salts distinguished by a termination in *ite*. Acids, of which the names end in *ic*, have their salts distinguished by a termination in *ate*. Thus, we have nitrite, and nitrate of potash—sulphite, and sulphate of soda. If there be a third acid, having still more oxygen, the letters *oxy* are prefixed. If the alkali be in excess, the word *sub* is prefixed; as sub-sulphate. If the acid be in excess, *super* is prefixed, as super-sulphate. The letters *bi* are placed before the name of a salt having a double proportion: hence carbonate, and bi-carbonate.

OF CERTAIN ELEMENTARY SUBSTANCES, CALLED ACIDIFIABLE, AND THEIR ACID AND OTHER COMBINATIONS.

ON CARBON, OR CHARCOAL.

Nature presents us with the most beautiful, and purest

* This practice, as respects oxides, has only extended to the instances here given. Carbon yields only one oxide and one acid, hence there is no carbonic oxide, nor carbonous acid.

specimen of this substance. The diamond is pure carbon. When equal weights of charcoal and diamond are severally exposed to the rays of a powerful lens, in oxygen gas, included in different bell glasses, they are both converted into carbonic acid. In like manner, when diamond powder is heated with nitre or iron, the effects are analogous to those which would arise from a quantity of charcoal.

Carbon is very abundant in nature, in the various forms of fossil coal; from anthracite, in which it is nearly pure and unallied with bitumen, to the highly bituminous variety called kennel or cannel coal. In bituminous coal, there is much hydrogen. Carbon pervades vegetable and animal matter as an essential element. It is, especially, a constituent of the fibres of wood.

OF THE METHODS OF OBTAINING CHARCOAL.

In the Laboratory, charcoal is obtained, sufficiently pure, by intensely heating wood in close vessels: in the large way, by igniting large quantities of wood, so covered with earth, that the access of air may at first be controlled, and afterwards prevented.

OF THE PROPERTIES OF CARBON.

It is usually black, inodorous, and insipid. Charcoal of wood is one of the best radiators, and worst conductors, of heat. There is reason for believing this peculiarity to result from its excessive porosity; as in the form of anthracite, carbon conducts heat better, and probably radiates it worse.* Wood-charcoal is highly susceptible of galvanic ignition. It was first fused by me, by means of the galvanic deflagrator.

With *abundance* of oxygen, carbon produces carbonic acid—with *an inadequate supply*, carbonous oxide. Carbon combines also with hydrogen, sulphur, and nitrogen; and, as lately ascertained, with chlorine; with which, however, it cannot be made to enter into combustion, even by the intense ignition of the voltaic pile.

* Lehigh coal is of the species called, by mineralogists, anthracite.

OF THE HIGHLY INGENIOUS EXPERIMENTS, AND OBSERVATIONS ON THE FUSION AND VOLATILIZATION OF CARBON, BETWEEN THE POLES OF THE GALVANIC DEFLAGRATOR, BY PROFESSOR SILLIMAN.

OF CARBONIC ACID GAS.

This gas constitutes about a hundredth part of the atmosphere, so that lime-water cannot be exposed to it, without becoming covered with a pellicle of carbonate of lime. Carbonic acid is an incessant product of combustion, and of the respiration of animals. It is a principal ingredient in marble and limestone.

ON THE PRODUCTION OF CARBONIC ACID, BY COMBUSTION:—
BY CALCINING CARBONATES:—BY ACIDS:—BY FERMENTATION:—BY RESPIRATION.

ON THE PROPERTIES OF CARBONIC ACID.

It causes precipitates in lime, barytic and strontitic waters, or in a solution of acetate of lead. It destroys life, and extinguishes flame. It is salubrious when dilute. Whether dilute or not, it is innocent in the *stomach*. Potassium burns in it. It may be absorbed by water, but is evolved from it unchanged, either by rarefaction, ebullition, or frost. It reddens litmus. It combines with earths and alkalies, forming carbonates. It is very antiseptic. Plants probably absorb it, retain its carbon, and give out its oxygen. The respiration of animals has the opposite effect.

EXPERIMENTAL ILLUSTRATIONS.

Evolution of the gas shown—also, its property of extinguishing a candle—Its difference from nitrogen, rendered evident by means of lime-water. When introduced into a vessel by means of a tube going to the bottom, it overflows, if redundantly supplied, as in the case of a liquid. Litmus, reddened by carbonated water—colour restored by boiling.

ON THE IMPREGNATION OF WATER, OR ALKALIES, WITH CARBONIC ACID.

OF IMPREGNATING APPARATUS.

WOULFE'S—NOOTH'S—PEPY'S, &C.—MY SUBSTITUTE FOR WOULFE'S—
 APPARATUS FOR REGULATING THE SUPPLY BY THE ABSORPTION. ON
 THE MEANS EMPLOYED IN THE MANUFACTURE OF ARTIFICIAL MINER-
 AL WATER.

OF CARBONOUS OXIDE.

Means of obtaining carbonous oxide.

It is obtained by calcining whiting with iron filings, in a gun-barrel, at a white heat.

PROPERTIES OF CARBONOUS OXIDE.

It is a gas highly deleterious to life, and incapable of supporting combustion. Even when diluted with air, it is pernicious, as it is to this we must ascribe the noxious influence of burning charcoal.

EXPERIMENTAL ILLUSTRATIONS.

Carbonous oxide gas evolved by process above mentioned, and collected in bell glasses over water—Combustion and detonation of it shown, and subsequent absorption by lime-water.

ON THE COMBINATIONS OF CARBON WITH HYDROGEN.
 OF CARBURETTED, AND SUPER-CARBURETTED HYDROGEN.

It is these varieties of inflammable gas, which principally form, when ignited, the flames of candles—lamps—and gas lights.

OF THE MEANS OF PROCURING CARBURETTED HYDROGEN.

Carburetted hydrogen is evolved by the distillation of wet charcoal; but, when thus procured, it is contaminated by carbonous oxide. It is generated purer by the destructive distillation of coal, oil, or tar, as in the gas light apparatus. The fire-damp, which has by its explosion, caused the death of so many miners, is an impure carburetted hydrogen.

OF SUPER-CARBURETTED HYDROGEN, OR OLEFIANT GAS.

Called olefiant, from its condensing, with chlorine, into the form of an oil.

OF THE MEANS OF OBTAINING OLEFIANT GAS.

The purest is obtained by passing alcohol through an ignited porcelain tube; or by distilling it with twice its bulk of sulphuric acid. It is probably the base of the ethers. It is very explosive with common air, and still more so with oxygen. Flame, appears to be luminous, in proportion to the carbon consumed in it. An excess of this element, beyond the quantity for which there is an adequate supply of oxygen, renders it smoky, and of course obscure. But substances, which when burned in the atmosphere, are on this account unpleasantly fuliginous, inflamed in oxygen, produce the most brilliant light.

ON THE OPPOSITE HABITUDES OF CARBON AND HYDROGEN WITH CALORIC, AND THE CONSEQUENT VARIETY IN THE VOLATILITY OF THEIR COMPOUNDS, FROM ANTHRACITE AND THE DIAMOND, TO NAPHTHA.

WHY MOISTURE CAUSES SOME MINERAL COALS, TO BURN BETTER.

ON MOREY'S WATER-BURNER.

ON THE SAFETY LAMP.

OF CARBURET OF NITROGEN, OR CYANOGEN.

Named from the colour of its flame, from *χυανος* blue.

OF THE MEANS OF OBTAINING CYANOGEN.

Distil prussiate of mercury in a coated glass tube, at a heat as nearly approaching to redness, as the glass will bear. The tube must have a smaller one adapted to it, to convey the gas under the bells, in the mercurial pneumatic cistern.

PROPERTIES OF CYANOGEN.

It is a true gas. It is characterized by burning with a beautiful blue flame. It is nearly twice as heavy as

common air. Water absorbs four and a half volumes, pure alcohol, twenty-three volumes. One hundred parts of it, detonated with oxygen, produce 200 parts of carbonic acid, and 100 parts of nitrogen. It is absorbed by alkalies, and alkaline earths. With hydrogen, it forms prussic, or hydrocyanic acid. In relation to the galvanic poles, it is electro-negative. An instance is thus afforded of the adventitious character of this species of polarity—since carbon and nitrogen, the elements of cyanogen, are both electro-positive.

EXPERIMENTAL ILLUSTRATIONS.

The gas evolved agreeably to the process above mentioned, and its blue flame exhibited.

COMPOSITION OR NATURE.

Cyanogen consists of one atom of carbon, and one atom of nitrogen.

ON SULPHUR.

It is a well known mineral production, sold in the shops, in rolls, under the name of brimstone—also in flowers. It is found pure in the vicinity of volcanoes, of which it is a product. In combination with metals, it is widely disseminated. From some of these, called pyrites, it is sublimed, in flowers, by heat.

PROPERTIES OF SULPHUR.

It is insipid, and inodorous, unless when burning—electric by friction—cracks from the warmth of the hand. At 180° F. it evaporates slowly, yielding an inflammable solution in air—melts at 225° —thickens between 350° and 400° —sublimes at 600° in flowers, which appear crystalline, when viewed by the microscope. Its purity may be proved by its total evaporation from platina leaf. It is soluble in boiling oil of turpentine. It combines with metals, earths, and alkalies, forming sulphurets. An acid precipitates it from solutions of alkaline, or earthy sulphurets. It forms with oxygen, the sulphurous and the sulphuric acids. Other combinations are alleged to

exist. The weights of oxygen, and sulphur, in sulphurous acid, are equal. In sulphuric acid, there is one half more oxygen. Sulphur combines with hydrogen gas, in two proportions, forming sulphuretted, and super or bisulphuretted hydrogen.

EXPERIMENTAL ILLUSTRATIONS.

THE COMBUSTION OF SULPHUR WITH COMMON AIR AND OXYGEN GAS, EXHIBITED BY MEANS OF APPROPRIATE APPARATUS.

THE COMBUSTION OF DUTCH GOLD LEAF BY SULPHUR—ALSO; COMBUSTION OF AN IRON BAR, SHOWN.

MEANS OF OBTAINING SULPHURIC ACID.

OF SULPHURIC ACID.

This acid is obtained, by burning sulphur and nitre, in leaden chambers, or by the old process of distilling copperas, or green vitriol; whence the almost obsolete name, oil of vitriol. It is best purified by distillation.

PROPERTIES OF SULPHURIC ACID.

It is a gas, when uncombined with water; but this absorbs so much of it, as to double its specific gravity nearly. Its aqueous solution is oleaginous in its consistency—caustic, when concentrated—intensely acid, when dilute—It heats greatly, when mixed with water, especially when to 73 parts of acid, 27 parts of water are added. Hot water explodes with it as with a melted metal. Its strength is reduced by the absorption of moisture, when exposed to the air.

EXPERIMENTAL ILLUSTRATIONS, OF THE PROPERTIES, AND THE MEANS OF PRODUCING, SULPHURIC ACID.

The production of sulphuric acid, shown in a large glass globe. Its effects, upon litmus—barytes—metals—and organic products, displayed: also, in heating water.

OF SULPHUROUS ACID.

MEANS OF OBTAINING SULPHUROUS ACID.

It is formed, when sulphur is burned under ordinary

circumstances: or, by boiling sulphuric acid on sulphur, mercury, and other substances, by which it may be partially de-oxidized.

PROPERTIES OF SULPHUROUS ACID.

It is a gas, intolerable to the organs of respiration, deleterious to life, and incapable of supporting combustion. Water takes up 33 times its bulk. Unlike other acids, it whitens litmus—bleaches silk and wool. It is decomposed by substances, which attract oxygen more powerfully than sulphur. When, on the other hand, oxygen is presented to it freely;—by absorbing this principle, it passes into the state of sulphuric acid.

OF SULPHATES, OR SALTS. FORMED BY SULPHURIC ACID WITH THE EARTHS, ALKALIES, AND OTHER OXIDES.

Their solutions, all yield precipitates with solutions of barytes. Heated with charcoal, they are converted into sulphurets, which, if moistened, smell like rotten eggs.

OF SULPHITES.

Sulphites are rarely met with. They are known by having the smell (especially when heated) of sulphurous acid gas. They pass, when in solution, or moistened, to the state of sulphates.

OF SULPHURETS.

MEANS OF OBTAINING SULPHURETS.

Sulphurets of the earths, and fixed alkalies are obtained by fusing, or boiling them with sulphur. When formed in the moist way, they are contaminated by sulphuretted hydrogen, which (water being present) is always formed by them. Sulphuret of ammonia is formed by one part quick-lime, one part muriate of ammonia, and half a part of sulphur, distilled at a gentle heat.

ON THE PROPERTIES OF SULPHURETS.

When moistened, they smell like rotten eggs, or the washings of a gun-barrel.—They change vegetable colours like alkalies—blacken the skin—and are decom-

posed by acids, yielding sulphur in a white precipitate. They absorb oxygen, and are, therefore, used in eudiometry. They are erroneously said, to effervesce violently with acids.

OF SULPHURETTED HYDROGEN GAS.

MEANS OF OBTAINING SULPHURETTED HYDROGEN.

This is most easily obtained from sulphuret of iron, by diluted sulphuric acid.

OF THE PROPERTIES OF SULPHURETTED HYDROGEN.

It is a permanent gas, with the odour, as already described, of rotten eggs—absorbable by water—inflammable, and explosive, forming, by combustion, with air or oxygen gas, water, and a mixture of sulphurous and sulphuric acids. It tarnishes metals; especially preparations of lead, of which it is a test, and by which it may be detected. It is evolved from privies—blackening the cerus, or carbonate of lead in paint. Its aqueous solution reddens litmus; combines with earths and alkalies, forming hydrosulphurets, and has, therefore, some attributes of acidity. It is found in native mineral waters. It is decomposed by various substances, having affinity for one or both of its constituents—as for instance, by chlorine—potassium—sodium—sulphurous acid—ignited carbon—and by successive electric explosions. Sulphuretted hydrogen decomposes all metallic solutions, unless those of iron, nickel, cobalt, manganese, titanium, and molybdena, in consequence of the attraction between hydrogen and oxygen, or chlorine; and between sulphur and the metals.

EXPERIMENTAL ILLUSTRATIONS.

Method of extricating sulphuretted hydrogen gas exhibited—also, the impregnation of water with it. Effects of its aqueous solution on litmus—and on various metallic solutions. Characters, written with dissolved acetate of lead, become black on exposure to the gas, or its aqueous solution.

ON HYDRO-SULPHURETS.

MEANS OF OBTAINING HYDRO-SULPHURETS.

They are obtained by saturating with the gas, as it is generated, alkalies, and earths, dissolved, or suspended in water. The apparatus, for impregnating carbonates, may be used for this purpose.

PROPERTIES.

Hydro-sulphurets all form colourless solutions in water, are changed to a greenish hue by time, and blacken the bottle, by deoxidizing the lead, in the glass. An acid discharges the sulphuretted hydrogen, by combining with the base. The hydro-sulphurets precipitate all metallic solutions; the solvent being attracted by the base, and the metal and oxygen by the sulphur and hydrogen. In analyses for metallic poisons, the hydro-sulphurets are of course useful.

EXPERIMENTAL ILLUSTRATIONS.

Production of hydro-sulphurets, shown—also, their effects on metallic solutions.

OF SULPHURETTED HYDRO-SULPHURETS.

They are said to exist always in solutions of sulphurets; and differ from simple hydro-sulphurets, only in containing a double proportion of sulphur.

METALLIC SULPHURETS.

They are treated of, under the head of their metals.

SULPHURET OF CARBON.

It is obtained, by passing sulphur, in vapour, over pieces of charcoal, intensely ignited, in a porcelain tube.

PROPERTIES OF SULPHURET OF CARBON.

It is colourless and transparent—acid—pungent to the taste—caustic—somewhat aromatic—smells nauseously, and is very inflammable, volatile, and difficult to freeze.

ON THE COMBINATIONS OF NITROGEN.

COMBINATIONS OF NITROGEN WITH OXYGEN.

OF NITRIC ACID.

Nitrogen gas and oxygen gas, are mixed in the air, without chemically combining; but, if subjected to a succession of electrical sparks, they form a chemical compound of a very active kind, called nitric acid. In this, they exist in proportions, nearly the reverse of those in which they constitute common air.

MEANS OF OBTAINING NITRIC ACID.

The production of nitric acid, by electricity, is too laborious to be resorted to for the purposes of the chemist. Possibly lightning might be made to produce it. The mode, usually employed, is to fuse nitre at a red heat, pulverize it, and distil it with one-half its weight of the strongest sulphuric acid, in glass, porcelain, or iron vessels.

PROPERTIES OF NITRIC ACID.

It is nearly one-half heavier than water—usually, orange coloured—when pure, colourless. It cannot be obtained free from water. It acts powerfully on almost all the metals,—also on organic substances, causing them to be oxydated. It stains and destroys the skin. It may be considered as the matter of atmospheric air, in the liquid form; but with ten times as much of the active principle, oxygen. It is the most energetic principle in gunpowder. It ignites oil of turpentine, charcoal, and phosphorus.

EXPERIMENTAL ILLUSTRATIONS.

The extrication and distillation of nitric acid, shown, by means of a glass retort and receiver, heated by a lamp—a chafing dish—or small sand bath. Its action on various substances exemplified.

OF NITROUS AIR, OR NITRIC OXIDE GAS.

MEANS OF OBTAINING NITRIC OXIDE.

It is evolved during the reaction, between strong nitric acid, and copper, silver, and other metals.

PROPERTIES OF NITRIC OXIDE GAS.

It is permanent over water, by which it is slightly absorbed:—is rather heavier than common air—It is not acid. It extinguishes a candle flame, but ignites Homberg's pyrophorus, and supports the combustion of phosphorus, if inflamed, before immersion in it. It is fatal to animals—renders the flame of hydrogen green by mixture—does not explode with it, but does explode with ammonia. It unites rapidly with the oxygen of the air, or of oxygen gas, or any gaseous mixture containing it, producing remarkable red acid fumes, which redden litmus paper, if pasted inside of the glass in which the mixture is made. Is absorbed by the sulphate or muriate of the black oxide of iron. The solution absorbs oxygen, and is, therefore, used in eudiometry.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF NITRIC OXIDE.

Extrication of the gas, shown by means of copper, or silver, and nitric acid—received in bells over mercury—self-regulating reservoir of nitrous gas, for eudiometrical experiments—absorption of oxygen gas, by nitric oxide, and the consequent acidity, made evident by the effect on litmus. Solution of nitric oxide in green muriate, or green sulphate of iron, exhibited, and its power of absorbing oxygen.

OF THE COMPOSITION OF NITRIC OXIDE.

It is decomposed by moistened iron filings: by ignited charcoal, arsenic, zinc, or potassium. It is supposed to consist of two atoms of oxygen, and one of nitrogen.

OF GASEOUS OXIDE OF NITROGEN, OR NITROUS OXIDE.

MEANS OF OBTAINING NITROUS OXIDE.

It may be obtained by the action of dilute nitric acid upon

zinc: by exposing nitric oxide gas to iron filings, sulphites, or other substances, attractive of oxygen. It is procured best from nitrate of ammonia, by distillation. The strongest acid may be saturated by the carbonate of ammonia of the shops, in the retort to be used for the distillation, and the distillation proceeded in forthwith. Nitrous oxide is advantageously kept in air bags, filled by an apparatus contrived by me. Water absorbs it.

RATIONALE OF THE FORMATION OF NITROUS OXIDE, BY THE DISTILLATION OF NITRATE OF AMMONIA.

PROPERTIES OF NITROUS OXIDE.

It is a permanent gas. Its weight to common air is as 16 to 10. It supports the combustion of a candle flame vividly; though nitric oxide gas, containing twice as much oxygen, does not. Phosphorus is difficult to inflame in it, but burns, with rapidity, when once on fire. The habits of sulphur are, in this respect, analogous to those of phosphorus. An iron wire burns in it, as in oxygen gas. Nitrous oxide may be exploded with hydrogen, forming water, and sometimes nitric acid. It combines with alkalies, only when nascent, which nevertheless remain alkaline. It has no attribute of acidity. It stimulates, and then destroys, life. Its effects on the human system are miraculous.

EXPERIMENTAL ILLUSTRATIONS.

The process for producing, catching, and breathing the nitrous oxide gas, exhibited. The effect on a lighted candle, and on an iron wire, shown.—Also, the effects of breathing the gas, on the human system.

OF THE NITRATES.

They are characterized by deflagrating with charcoal, and decomposition per se, by heat, leaving a residuum of their base. Chlorates also deflagrate with charcoal, but are rarely met with—and leave a chloride, after exposure to a red heat. Nitrate of potash, or nitre, is one of the most important productions of nature, forming five-sevenths of the ingredients in gunpowder. It is obtained by lixiviation, from the soils of certain territories in India and

Spain, and other countries;—also from the earths of cellars, and large caves.

OF NITROUS ACID.

This acid, or its combinations, are rarely met with. The existence of an acid, containing less oxygen than nitric acid, and more than nitric oxide, seems evident, from the red acid fume, arising on the mixture of nitric oxide with oxygen gas. This fume cannot be nitric acid, since its fume is white.

When the nitrates, with a fixed base, are heated to a red heat, for a short time, they appear to be converted partially into nitrites.

OF THE COMPOUNDS OF CHLORINE.

OF MURIATIC, OR HYDROCHLORIC ACID.

Chlorine and hydrogen gases, when mixed in equal volumes, slowly combine, and form muriatic acid. If exposed to light, or the electric spark, a detonation ensues. The direct rays of the sun are not necessary, according to Silliman's experiments. When dry, muriatic acid is produced in the form of a gas; but if moist, in the form of a liquid.

MEANS OF OBTAINING MURIATIC ACID GAS.

Distil two parts of common salt, with one part of sulphuric acid in a glass, porcelain, or iron retort.

PROPERTIES OF MURIATIC ACID GAS.

It has all the attributes of a gas.—It is colourless, to the organs of respiration, intolerably irritating, and, if not very dilute, deleterious to life. On escaping into the air, it produces white fumes, from its meeting with aqueous vapour. Its affinity for water, is so great, that this liquid will take up 420 times its bulk, and ice melts in it, as if surrounded by fire. The alkaline metalloids decompose it, by combining with its chlorine, while its hydrogen separates in the gaseous state. It is susceptible both of decomposition, and recomposition, by electricity. Equal weights of potassium separate the same weights, or vo-

fumes of hydrogen, from muriatic acid, and from water; a result coincident with the atomic theory. Muriatic acid gas is resolved, when electrified with oxygen, into water and chlorine. It combines with pure barytes and strontites, producing a chloride, and water. On being mixed with ammoniacal gas, very dense fumes are produced of muriate of ammonia. The fumes arising thus from the mixture of ammonia and muriatic gas, enables us to detect either, by the other.

EXPERIMENTAL ILLUSTRATIONS.

Generation of the gas shown;—also, its collection in glasses, and its absorption by water or ammonia—also, the liquefaction of ice by it.

OF LIQUID MURIATIC ACID.

OF THE MEANS OF OBTAINING LIQUID MURIATIC ACID.

It is obtained, by saturating water with the gas, in a Woulfe's apparatus,—or in mine. The solution is nearly pure, in all the receptacles, excepting the first. The liquid acid is also procured, by distilling a solution of common salt with sulphuric acid, and condensing the product in a receiver.

PROPERTIES OF LIQUID MURIATIC ACID.

When concentrated, it produces suffocating fumes, from an escape of gas. When pure, it is colourless; though usually straw-coloured, from a minute adulteration by iron. Muriatic acid *can be said to combine with those alkalies, earths, and oxides only, which form with it, soluble salts*. Its combinations are, for the most part, by heat, and desiccation, convertible into chlorides;—muriate of magnesia, and muriate of alumine, are exceptions—also muriate of ammonia, of which there can be no chloride, since chlorine decomposes it, by its affinity for hydrogen.

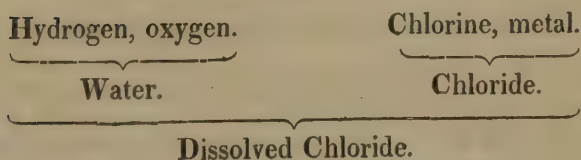
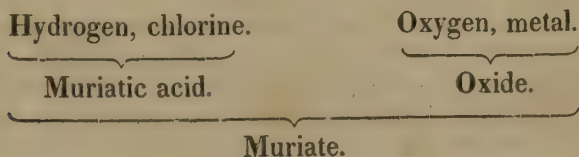
EXPERIMENTAL ILLUSTRATIONS.

Evolution of the gas from a retort, containing common salt and phosphoric acid, aided by heat. Gas collected over mercury in tall jars. Water coloured by litmus, be-

ing introduced, rapidly changes to a red colour, and causes the disappearance of the gas. Ice introduced, fuses quickly, and absorbs the gas. Ammonia being mixed with it in due proportion, dense fumes of sal ammoniac ensue. The gas being passed through water in an impregnating apparatus, the aqueous solution is obtained.

ON THE DIFFERENCE BETWEEN A CHLORIDE IN SOLUTION AND A MURIATE.

A chloride in solution contains the same elements as a muriate, but in a different order, as may be seen by writing them down as follows.



In the case of barytes, strontites, lime, potash, and soda, the last mentioned order is probable; because when heated, the oxygen and hydrogen escape, as water—the chlorine and metal remaining in union. In the case of magnesia and alumina, the oxygen remains with the metal, while the other elements escape, as muriatic acid. Besides these equivocal compounds, there are substances, formerly called muriates, now decidedly considered as chlorides. As, for instance, calomel, luna cornea, plumbum corneum, butter of antimony, or of bismuth, fuming liquor of Libavius, and other metallic combinations, either insoluble in water, or incapable of mixing with it, without some striking change.

GENERIC CHARACTER OF MURIATES, OR SOLUBLE CHLORIDES.

They precipitate solutions of silver, lead, or black oxide of mercury. When concentrated, they give off muriatic acid as, by the affusion of sulphuric acid. They are not generally decomposable by heat. Muriate of magnesia is the only important exception. They do not deflagrate with charcoal; nor do they, like sulphates, after being heated with it, on being moistened, yield the odour of sulphuretted hydrogen.

COMPOUNDS OF CHLORINE WITH OXYGEN.

Chlorine, passed into alkaline solutions, decomposes water—forms muriatic acid with hydrogen—and another acid with oxygen called chloric acid. The acids thus generated, form severally, chlorates and muriates.

ON THE CHLORATES.

ON THE PROCESS FOR OBTAINING THEM.

ON THE PROPERTIES OF THE CHLORATES.

They deflagrate like the nitrates, but leave a residuum of chloride, after the ignition. They furnish the purest oxygen. When mixed with combustibles, as sulphur or phosphorus, they ignite by triture, or percussion—also by the affusion of sulphuric acid. With the same acid, they inflame alcohol and oil of turpentine, and phosphorus even under water.

EXPERIMENTAL ILLUSTRATIONS.

Chlorate of potash, and sulphur, being separately pulverized, and then mixed, a blow, or friction, causes the mixture to explode. Phosphorus being minced by a knife, and mingled with chlorate, a portion of the mixture, rubbed by a pestle, explodes. Another portion being allowed to sink to the bottom of a glass vessel containing water, sulphuric acid is poured down by means of a tube, when a brilliant ignition ensues.

OF EUCHLORINE, OR OXIDE OF CHLORINE.

OF THE MEANS OF OBTAINING EUCHLORINE, OR OXIDE OF CHLORINE.

It is obtained by heating, gently, a portion of chlorate of potash, under about twice as much muriatic acid, of moderate strength, as will cover it. The retort should only be subjected to the flame of a small spirit lamp. This should be applied immediately under the acid, so as not to heat the body of the vessel,—otherwise an explosion will probably take place.

OF THE PROPERTIES OF EUCHLORINE, OR OXIDE OF CHLORINE.

Euchlorine is gaseous, but absorbable by water, to the extent of eight or ten times its volume. It is a binary compound of one atom of oxygen, and one of chlorine. The warmth of the hand, is sufficient to cause it to detonate, and to separate into its gaseous elements, occupying one-fifth more space. Antimony, or arsenic, in powder, or Dutch leaf, causes it to explode, by an attraction for the chlorine.

EXPERIMENTAL ILLUSTRATIONS.

Euchlorine, generated by the process above-mentioned, and collected over mercury. A tube, filled with it, is made to explode by surrounding it by a red-hot iron ring. Enlargement of bulk, after the explosion, shown, and subsequent absorption of the chlorine by the mercury. The residual gas shown to be oxygen. Portions of euchlorine exploded, by Dutch gold, antimony, or arsenic.

OF PEROXIDE OF CHLORINE.

OF THE MEANS OF OBTAINING PEROXIDE OF CHLORINE.

It is obtained by mixing chlorate of potash, with sulphuric acid, and distilling with great caution, at a heat below 212° . The process is too dangerous for familiar repetition.

OF THE PROPERTIES OF PEROXIDE OF CHLORINE.

They are those of euchlorine, but are more intense. It is generally considered as a deutoxide of chlorine. According to Brande, it is only a purer euchlorine.

OF CHLORIC ACID.

MEANS OF OBTAINING CHLORIC ACID.

It is obtained by passing chlorine through water, containing oxide of silver in suspension.

OF THE PROPERTIES OF CHLORIC ACID.

It is colourless—sour and astringent. When warm and concentrated, its odour is pungent. It reddens litmus. It does not precipitate solutions of lead, mercury, or silver. It is partially decomposed by distillation. With muriatic acid, it produces water, and chlorine.

OF THE COMPOSITION OF CHLORIC ACID.

It is supposed to consist of one atom of chlorine, and five atoms of oxygen.

OF NITRO-MURIATIC ACID.

It is obtained by mixing nitric with muriatic acid.

PROPERTIES OF NITRO-MURIATIC ACID.

The colour of nitro-muriatic acid is much deeper than that of its constituent acids; and its fumes are more pungent, being evidently chlorine, the muriatic acid having been dehydrogenated by the oxygen of the nitric acid. The effects of nitro-muriatic acid are much the same as those of a solution of chlorine in water, excepting that there is a greater quantity in the nitro-muriatic acid in the same space. Nitro-muriatic acid is the usual solvent of platina and gold.

ACTION OF CHLORINE ON GOLD.

Some gold leaf is placed in two glasses—nitric acid is added to one glass, and muriatic acid to the other glass :

The gold is not acted upon. The contents of one glass being added to the other, the gold disappears.

ON THE COMPARATIVE ACTION OF SULPHURIC, NITRIC, MURIATIC, AND NITRO-MURIATIC ACIDS.

Sulphuric acid carbonizes organic products, by its avidity for the elements of water. In this respect, its action more resembles that of caustic alkalies than of acids. When boiled on metals, they are oxidized at its expense. When cold and diluted with water, the metals, on which it acts are oxidized, at the expense of the water.

Whether cold or hot nitric acid acts, both on metals and upon organic products, by imparting oxygen. Hence, when cold, its action on metals is the same, as that of sulphuric acid, when boiling.

The action of muriatic acid on organic products is very slight:—upon metals, with heat, it resembles that of nitric acid, and boiling sulphuric acid; excepting, that it imparts chlorine, instead of oxygen. When it acts on metals in the cold, it evolves hydrogen; which may come from the decomposition of the acid, though usually supposed to arise from the decomposition of water. The water may be decomposed when added; and dilute sulphuric and muriatic acids may both be considered as containing simple radicals, acidified by the joint agency of hydrogen and oxygen.

ON THE BLEACHING PROCESS.

ON THE OLD THEORY OF THE NATURE OF CHLORINE.

Muriatic acid was deemed to be a compound of oxygen and some unknown radical.—When distilled from oxide of lead, or manganese, it was supposed to combine with a portion of the oxygen of the oxide, forming oxygenated muriatic acid. The oxygen was supposed to be held by a weak affinity, as in nitric acid. Hence the combustion of substances in the gas—and hence its power, as a solvent of metals. It has since been proved, that, when dry, it does not oxygenate. Charcoal is not acted upon, when ignited in dry chlorine by voltaic electricity. Metals,

burned in it, are not oxidated, but converted into peculiar substances. Sulphur and phosphorus are not acidified by it. If chlorine be an oxygenated acid, the discovery of euchlorine, and chloric acid, must establish the following anomaly—that the radical of muriatic acid, acidified by oxygen, on further additions of the acidifying principle loses its acidity, and forms two oxides—chlorine and euchlorine; and yet, by a subsequent addition of the same principle, regains the acid state.

Thenard has lately oxygenated muriatic acid; or, more properly, the water in it.

The fluid thus containing muriatic acid and oxygen in excess, has no resemblance to chlorine.

The process, by which iodine is obtained from hydriodic acid, is analogous to that, by which chlorine is obtained from muriatic acid;—yet iodine is not considered as an oxygenated acid.

OF PHOSPHORUS.

MEANS OF OBTAINING PHOSPHORUS.

It is obtained from the phosphate of soda in urine, or the phosphate of lime in bones. Phosphoric acid is extricated from the earth of bones, by the stronger affinity of sulphuric acid.* Phosphoric acid is decomposed by ignition with charcoal in a retort, from which it distils in tears, which are melted and strained under water. The phosphate of soda is decomposable by nitrate of lead, by complex affinity. The resulting phosphate of lead is decomposable by distillation, at a high heat, with carbon.

OF THE PROPERTIES OF PHOSPHORUS.

It is often of a light flesh colour—but when pure is colourless and translucent. It is rather harder than wax, but more easily split by the knife, under which, after some pressure, it yields suddenly. It boils at 550° F. and in a retort filled with hydrogen may be distilled. By these means, it may be separated from the phosphuret of

* The phosphoric acid is said to be in the state of a super-phosphate of lime when thus obtained.

carbon, which, more or less, according to Thenard, always contaminates it. Hydrogen is evolved by electro-chemical action; but is present in the phosphorus, as an impurity, not as a constituent. Phosphorus is susceptible of a slow, and of a quick combustion, producing phosphorous and phosphoric acids. The existence of other compounds of phosphorus, and oxygen has been alleged.

OF PHOSPHORIC ACID.

MEANS OF OBTAINING PHOSPHORIC ACID.

It is obtained, not only, as above mentioned, by the combustion of phosphorus, or decomposition of bones, but by adding phosphorus, gradually, to nitric acid, heated in a retort.

OF THE PROPERTIES OF PHOSPHORIC ACID.

Though composed of volatile ingredients, phosphoric acid is one of the most fixed and per se unalterable acids, by heat. Evaporated to dryness, and fused, it forms a glass. It is soluble in water—is not odorous. It is supposed to consist of two atoms of oxygen, with one atom of phosphorus.

OF PHOSPHOROUS ACID.

MEANS OF OBTAINING PHOSPHOROUS ACID.

It is obtained, by slow combustion; but is then contaminated by phosphoric acid: better, by the distillation of phosphorus with corrosive sublimate. Chloride of phosphorus results, which, when mixed with water, produces muriatic and phosphorous acids. The muriatic acid, being most volatile, may be separated by heat.

OF THE PROPERTIES OF PHOSPHOROUS ACID.

It is distinguished from phosphoric acid, by its odious smell, and susceptibility of volatilization.

It consists of one atom of oxygen and one of phosphorus.

OF THE PHOSPHATES AND PHOSPHITES.

They have the same relation to each other, as sulphates

and sulphites—and nitrates and nitrites. The earthy and alkaline phosphates are not decomposed by ignition in contact with charcoal. The metallic phosphates yield phosphorus, when so treated. Hence the necessity of transferring the acid, from soda, to lead, in one of the processes for obtaining phosphorus.

OF HYPO-PHOSPHOROUS, OR PER-PHOSPHOROUS ACID.

This acid is said to consist of two atoms of phosphorus, and one atom of oxygen.

OF PHOSPHORUS AND CHLORINE.

There are two chlorides of phosphorus—a chloride and a bi-chloride. The latter is solid, and consists of one atom of phosphorus, and two atoms of chlorine;—the other, of one atom of phosphorus and one of chlorine. The deuto, or bi-chloride produces, with water, muriatic and phosphoric acids; while the chloride, or proto-chloride, produces muriatic, and phosphorous acids, with water.

OF THE COMBINATIONS OF PHOSPHORUS WITH THE ALKALIES, AND EARTHS CALLED PHOSPHURETS.

ON THE ANALOGY BETWEEN PHOSPHURETS, AND SULPHURETS, BOTH AS TO THEIR PRODUCTIONS, AND EFFECTS UPON WATER.

EXPERIMENTAL ILLUSTRATIONS.

Decomposition of water by the phosphurets of lime, and potash. Spontaneous combustion and detonation of bi-phosphuretted hydrogen, in atmospheric air, and in oxygen gas.

OF THE COMBINATION OF PHOSPHORUS WITH SULPHUR.

OF BORACIC ACID.

There is a salt, called borax, found in Thibet and China, which consists of this acid and soda in excess.

OF THE MEANS OF OBTAINING BORACIC ACID.

To a saturated solution of borax, add half the weight of the salt, in sulphuric acid. The boracic acid crystal-

lizes, by precipitation, in shining scaly crystals, contaminated by sulphuric acid, till purified by fusion. Boracic acid is fusible into a glass—decomposable in the Voltaic circuit into oxygen, and an olive-brown matter, which is considered as the base of the acid, and is called boron. By means of potassium, which combines with the oxygen of the acid, boron may be procured, in greater quantity, in the form of a dark olive powder.

OF BORON.

This substance, as above obtained, takes fire in the air at 600° F. and burns brilliantly when ignited in oxygen gas. It is acidified, when exposed to nitric, or sulphuric acids.

OF BORATES.

Borax, or sub-borate of soda, above spoken of, is the only important combination under this head. Fused into a glass, it is of great use in blowpipe assays, and in soldering.

OF FLUORIC ACID.

OF THE MEANS OF OBTAINING FLUORIC ACID.

Fluor spar is pulverized, and heated with twice its weight of strong sulphuric acid, in a leaden retort, adapted to a leaden receiver, surrounded by snow and salt. The acid condenses in a liquid state in the receiver.

OF THE PROPERTIES OF FLUORIC ACID.

It is so volatile that it cannot, in a close apartment, be decanted, without subjecting the operator to intolerable fumes. This operation must be performed where there is a current of air to carry them off. It ulcerates the skin wherever it falls. It corrodes glass so rapidly as to leave an indelible trace in running over its surface. It must be kept in vessels of silver or lead, accurately

closed. It may also be received in water, in which it may more easily be condensed and preserved.

EXPERIMENTAL ILLUSTRATIONS.

Powdered fluor heated with sulphuric acid, in a leaden retort, adapted to a receiver surrounded by snow and salt. Same process, substituting a receiver with water, by means of Knight's apparatus. Effects upon glass shown.

OF THE NATURE OF FLUORIC ACID.

It is probably composed of hydrogen, and a principle called fluorine, supposed analogous to chlorine and iodine, and which forms acids with hydrogen, silicon, and boron.

PROOFS OF THE EXISTENCE OF FLUORINE, FOUNDED ON VOLTAIC ANALYSIS.

OF FLUORIDE OF SILICON, OR, FLUO-SILICIC ACID GAS, USUALLY CALLED SILICATED FLUORIC ACID.

It is obtained by adding, to the materials for producing pure fluoric acid, one half the weight of the fluor, in powdered glass, in a glass retort, and distilling. The product, being gaseous, is received in bell glasses, over mercury.

PROPERTIES OF SILICATED FLUORIC, OR FLUO-SILICIC ACID.

It is a gas permanent over mercury. On mixing with air, it fumes, in consequence of the moisture, in which respect, as well as in its odour, and other obvious habits, it much resembles muriatic acid. When presented to water, a white deposition takes place, while the gas appears to be absorbed. This deposition was heretofore considered as pure silex. According to Brande, the gas, on meeting with water, forms two compounds, of fluoric acid with silex—one insoluble and insipid, the other soluble and acid.

EXPERIMENTAL ILLUSTRATIONS.

Production of the fluo-silicic acid shown. Its absorption by water—precipitation of silex.

OF THE FLUATES, OR, MORE PROPERLY, FLUORIDES.

The fluates are not of much importance in the arts. The alkaline fluates are tests for lime.

The fluates, so called, are properly fluorides; as are the muriates, when yielding chlorides (not oxides) by heat.*

FLUORINE WITH BORON.

FLUO-BORIC ACID GAS, OR FLUORIDE OF BORON.

It is obtained by distilling fluor spar, in powder, with dry boracic acid, (in the proportion of one part of the acid to two parts of the fluor or fluoride of calcium), in an iron tube at a strong heat. Or the same materials may be distilled, by means of a glass retort, with twelve parts of sulphuric acid.

Fluo-boric acid gas is produced, and may be collected, in the gaseous state, over mercury.

PROPERTIES OF FLUORIDE, OF BORON, OR FLUO-BORIC ACID GAS.

It is analogous to fluoride of silicon, but more intensely attracts moisture. Water absorbs 700 times its bulk, becoming nearly as heavy, and corrosive of organic matter, as concentrated sulphuric acid. In this state, it appears to consist of the same elements as fluoric and boracic acids;—but, as it does not corrode glass, there seems to be an intimate union of the fluorine with the boron, as well as with the hydrogen.

* See page 41.

END OF PART II.

MINUTES

OF THE

COURSE OF CHEMICAL INSTRUCTION,

IN THE

MEDICAL DEPARTMENT

OF THE

UNIVERSITY OF PENNSYLVANIA,

BY

ROBERT HARE, M. D.

PROFESSOR OF CHEMISTRY.

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1823.

*The acid of arsenic or acids has
given in intermittent form
in the formation of one sixth of
a grain*

MINUTES,

&c. &c.

OF THE METALS.

BESIDES the alkaline metalloids already treated of, there are twenty-nine metals. Their names are: gold, platina, silver, mercury, rhodium, palladium, iridium, osmium, copper, iron, nickel, tin, lead, zinc, bismuth, antimony, tellurium, selenium, arsenic, cobalt, manganese, chrome, molybdenum, uranium, tungsten, titanium, columbium, cerium, cadmium.

GENERIC CHARACTERISTICS OF THE METALS.

Substances belonging to this class have a specific gravity, not less than six, and, when newly cut, a peculiar lustre. They are the best conductors of heat and electricity; the worst radiators, and best reflectors of radiant heat. All combine, directly or indirectly, with oxygen, chlorine, and sulphur, in one or more proportions; forming oxides, chlorides, and sulphurets; and all are susceptible of solidity and fluidity, and probably of the æriform state. Mercury and arsenic are easily volatilized; and gold, silver, and platina, though very difficult to burn or volatilize, are nevertheless dissipated and oxidized by means either of the compound blowpipe, galvanism, or electricity.

OF THE PROPERTIES POSSESSED BY SOME METALS, BUT NOT BY OTHERS.

The properties which come under this head are: permanency of lustre in the fire and air—malleability—ductility—elasticity—sensibility to the magnet—susceptibility of the welding process—and of acquiring by a union with carbon, silicon, or aluminum, the property of hardening by sudden refrigeration.

The metals remarkable for permanency of lustre are, gold, platina, silver, and palladium. Those principally remarkable for malleability are, gold, silver, platina, copper, palladium, iron, tin, lead. Among these, iron and platina only, can be advantageously hammered at a very high temperature.

The metals distinguished for elasticity are, iron, copper, and silver. It is a quality which appears dependent on the approximation of their particles, and expression of their caloric by the hammer, rollers, or wire drawing. Iron, in the state of steel, when duly tempered, is pre-eminent for this property.

The metals remarkable for ductility are, gold, iron, (either as iron or steel,) silver, copper, platina, tin and lead. In large rods or pipes, lead and tin are the most ductile.

The magnetic metals are, iron, whether pure, in the state of steel, or in that of protoxide, and nickel. Those susceptible of the welding process are, iron, and platina. Iron only, is capable of uniting with carbon, silicon, or aluminum, and of hardening by quick refrigeration. Gold and platina are distinguished by their superior gravity, which is between two and a half, and three times greater, than that of iron, tin, or zinc, and twice as great as that of lead. The gravity of mercury is about one third less, that of lead one half.

The perfect metals are those which, like gold, silver, platina, and palladium, possess ductility and malleability, and which are not tarnished by exposure to the air, or oxidized by the highest heats of the air furnace or forge.

OF THE BRITTLE METALS, OR SEMI-METALS.

The latter appellation was given to those metals, which, like bismuth, antimony, cobalt, &c. could not, from their brittleness, be wrought under the hammer. They are now called, by some chemists, brittle metals. Zinc, till lately, was placed among the semi-metals; but, at this time, ought to stand between the two classes, being laminable by rollers, but not malleable.

OF ALLOYS.

This term is given to the compounds formed by the union of different metals. Thus the silver or gold used in coin contains copper; the gold or silver used by the smiths contains still more. Brass consists of copper and zinc. Pewter, of lead and tin, or tin, copper, and antimony.

OF AMALGAMS.

THESE ARE THE COMPOUNDS OF MERCURY WITH OTHER METALS.

OF THE NOMENCLATURE OF METALLIC OXIDES, CHLORIDES,
AND SULPHURETS.

Metals are susceptible of different degrees of oxidization. To distinguish these, the terms protoxide, deutoxide, and tritoxide, are used, to designate the first, second, and third degree. That oxide which contains most oxygen, is called the peroxide. In like manner, chlorine and sulphur combine in different proportions. Hence we have proto-chloride and proto-sulphuret, deuto-chloride and deuto-sulphuret, and per-chloride and per-sulphuret; also, chloride and bi-chloride, sulphuret and bi-sulphuret, or super-sulphuret.

OF GOLD.

MEANS OF OBTAINING GOLD.

Gold is occasionally found in nature, nearly pure. It is not liable, like other metals, to be degraded by a union with oxygen or sulphur. The precipitate produced in a solution of gold, in nitro-muriatic acid, by green sulphate of iron, is pure gold. Gold is also purified by exposure to heat and air, or nitric acid, by which means baser metals are oxidized, as in the processes of cupellation and parting.

Minute portions of gold are collected from the sands or ores in which they exist naturally, by trituration with mercury, in which they dissolve. They are separated from the mercury by distillation.

OF QUARTATION AND PARTING—OF CUPELLATION.

PROPERTIES OF GOLD.

Its colour and lustre are well known. Its gravity is 19.3; that is, the weights of equal bulks of gold and water, are, to each other, as 19.3 to 1. It is the most malleable and ductile metal, and suffers the least by exposure to air and moisture. Gold leaf, which is about 1000 times thinner than printing paper, retains its lustre in the air. Gold leaf transmits a greenish light, but it is questionable, if it be truly translucent:—Placed on glass, and viewed by transmitted light, it appears like a retina. It is erroneously spoken of, as a continuous superficies.

Gold fuses at a low white heat, but requires the temperature produced by the compound blowpipe, or galvanism, or the explosive power of electricity, to volatilize or oxidize it. Its insusceptibility to injury from exposure, is due to its weak affinity for oxygen or sulphur. But one oxide of gold is usually spoken of.—According to Berzelius, there is another oxide, containing less oxygen.

Neither sulphuric, nor nitric acid, has any action on gold. With the deutoxide, of Berzelius, they combine, but the compounds, thus formed, are not crystallizable.

It has been already stated, that chlorine exercises a very energetic affinity with gold. A combination between them ensues, whether the metal be heated in the gas, or presented to it in the aqueous solution, or in nitromuriatic acid.* The dissolved chloride, or muriate of gold, yields triple salts with the alkalies. The compound formed with ammonia, fulminates by percussion, or at a heat of about 400° F.

Sulphuretted hydrogen precipitates gold in the state of a sulphuret, which may be dissolved by liquid alkaline sulphurets.

When a solution of muriate of gold is mixed with sulphuric ether, the ether takes the metal from the acid and dissolves it. If iron or steel be moistened with this ethereal solution, it is productive of a slight gilding.

Phosphorus, carbon, and the baser metals, also hydrogen gas and its compounds, by attraction for oxygen,

* See pages 6 and 44, Minutes, 2nd part.

precipitate gold in the metallic form. Muriate of tin, or tinfoil, furnishes a purple precipitate, which is a compound of gold with tin. Hence tin, especially in the state of muriate of the protoxide, or dissolved protochloride, is the best test for gold.

Gold combines with almost all the metals, and amalgamates eagerly with mercury.

EXPERIMENTAL ILLUSTRATIONS.

Gold dissolved by nitro-muriatic acid, and precipitated by sulphate of iron, or by muriate of tin. A cylinder of phosphorus immersed in a solution of the metal, acquires the appearance of a cylinder of gold. Separation of gold, from its solution, by ether. Effects of the ethereal solution exhibited. Action of mercury on gold leaf.

OF PLATINA, OR PLATINUM.

MEANS OF OBTAINING PLATINA.

This metal, in the crude state of its native grains, as it comes from South America, may be dissolved in nitro-muriatic acid. A solution of sal ammoniac being added, an orange coloured precipitate results, of ammoniacal muriate of platinum. Ignition develops the metal from this precipitate, but in a divided state. By intense pressure, the minute particles, thus procured, are made to cohere, so far, as to sustain the welding process. By this they are made to coalesce, into a perfectly solid and coherent mass.

PROPERTIES OF PLATINUM.

Its colour is intermediate between that of silver, and steel. It is the heaviest body in nature, being about twice as heavy as lead, and nearly three times as heavy as iron. A cubic inch weighs nearly a pound. It is less ductile and malleable than gold, but harder and more tenacious—though, in these respects, inferior to iron. Like iron, it is susceptible of being hammered and welded at a white heat. It can neither be oxidized nor melted, by the highest temperatures of the air furnace, or forge.

It was first fused in a focus of the solar rays—afterwards by means of a stream of oxygen gas on ignited charcoal—but much more easily by my compound blowpipe, under which, it was first oxidized and dissipated by heat. It fuses and burns easily in the voltaic circuit, and is dispersed and oxidized by mechanical electricity. It is one of the worst conductors of heat among metals.

In its habitudes with oxygen, chlorine, or the acids, it is very analogous to gold, being, like that metal, detected by muriate, or proto-chloride of tin, which produces a claret colour with platina. It unites so energetically with tin, at a red heat, as to occasion the phenomena of combustion. With mercury it amalgamates by trituration, when in a divided state, as obtained by igniting the ammoniacal muriate.

PRACTICAL ILLUSTRATIONS.

Platina exhibited, in the state of native grains, and in that of larger masses. Precipitated from its solution, by muriate of ammonia, and muriate of tin. A precipitate produced in salts of potash, by muriate of platina, distinguishes them from salts of soda. Combustion of platina with tin-foil.

OF SILVER.

MEANS OF RENDERING SILVER PURE.

A solution of silver coin, in nitric acid, may be precipitated by mercury, and the precipitate ignited to drive off the mercury, which adheres to the precipitate. The first portions of the precipitate, obtained by means of copper, are sufficiently pure. The chloride obtained from the same solution, by common salt, ignited with pearlash, gives pure silver; and it may also be produced, by simply igniting the white crystals, which result, on evaporating the solution, or which spontaneously form in it, when sufficiently concentrated.

In malleability, silver is inferior to gold only. It is also very ductile, and tenacious. Its specific gravity is 10.5. It is the best conductor of caloric. It fuses at a low white heat. It is as difficult to oxidize in the fire, as gold, but is more liable to tarnish, when indiscriminately exposed in the atmosphere, from its susceptibility to the

action of sulphur and chlorine. Hence it is blackened by eggs, and salt water.

By the compound blowpipe, by electricity, or by galvanism, silver is fused, oxidized, and dissipated, as gold is by the same means. Exposed to nitric acid, it is oxidized by one portion, and dissolved by the other. In fact, this acid is its proper solvent. Sulphuric acid has no reaction with silver, when cold. At a boiling heat, the metal is oxidized at the expense of one portion of the acid; and the oxide, thus formed, is dissolved by another portion, as in the case of nitric acid.

Silver unites with chlorine, when heated in it. The chloride of silver, is one of the most insoluble combinations. Hence silver is not soluble in nitro-muriatic acid; and hence, soluble chlorides yield a precipitate when solutions of this metal are added to them: for, in any mixture, those substances will usually unite, which when united, are most insoluble. Gravity, unbalanced by attraction for the solvent, aids in separating them from substances which are so attracted.

Nitrate of silver, fused, forms lunar caustic; the fused chloride forms horn silver, or luna cornea.

Silver combines with iodine, and sulphur. It forms several fulminating compounds.

EXPERIMENTAL ILLUSTRATIONS.

Oxidizement and solution of silver in nitric acid. Its precipitation by muriates, phosphates, chromates, arsenites, exhibited: also by copper and mercury. Detonation of fulminating silver.

OF MERCURY, OR QUICKSILVER.

MEANS OF PROCURING MERCURY.

This metal may be found in nature, nearly pure, but much more abundantly in the state of sulphuret, from which it is obtained in purity, by distillation with substances calculated to detain the sulphur.

OF THE PROPERTIES OF MERCURY.

It is the only metal, which is fluid at the ordinary temperatures of the atmosphere. In colour and brilliancy it

resembles, and rivals silver. Its specific gravity is 13.5. At -39° F. it freezes into a malleable solid, and boils at about 660° of the same scale. It forms two oxides, two chlorides, and two sulphurets. The protoxide, or oxide, containing one proportion of oxygen, is black—the deutoxide, containing two proportions, red. The black oxide may be formed by mechanical agitation without heat—the red, by long exposure to heat; the air having free access in both cases. The red oxide, is usually obtained by decomposing the nitrate of mercury by heat; when thus formed, it retains some nitrogen. It is decomposed at the temperature, at which mercury boils.

When nitric acid, whether cold or hot, is poured on mercury, one portion of the acid is decomposed, imparting oxygen to the metal. The oxide, thus formed, is dissolved by the remaining portion of the acid. When the metal is in excess, the protoxide is principally formed. When the acid is in excess, the deutoxide predominates. Usually, more or less of each oxide is formed. The crystals of the nitrate of the black oxide, are white; those of the nitrate of the red oxide, yellowish.

No reaction arises from adding cold sulphuric acid to mercury; but, when it is boiled on mercury, the phenomena are similar to those which ensue in the case of nitric acid. One portion of the acid, yields oxygen to the metal, the other, combines with the oxide thus created. Each oxide of mercury, forms three salts with nitric acid; a sub, a super, and neutral nitrate. The neutral nitrates of mercury, subjected to water, yield insoluble sub-nitrates, and soluble super-nitrates. The same is true of the sulphate of the deutoxide, which yields turpeth mineral, or the insoluble sub-sulphate, and the soluble super-sulphate, by the affusion of hot water. The nitrate of the protoxide, gives calomel, or proto-chloride of mercury, when presented to muriate of soda. The nitrate of the deutoxide yields, under like circumstances, deuto-chloride of mercury, or corrosive sublimate. Thus a single proportion of oxygen in the oxide, disengages a single proportion of chlorine; and in like manner, a double proportion of oxygen disengages a double quantity

of chlorine. The complex affinity which causes these changes, operates either in the wet, or dry way; that is, whether the substances are mixed in solution, or sublimed together. The sulphate of the deutoxide of mercury produces these results, when sublimed with certain compounds of chlorine, as common salt for instance. Corrosive sublimate is thus procured, and, by trituration with mercury, a second sublimation, and washing in water acidulated with muriatic acid, may be converted into calomel, or proto-chloride. Or the deuto-sulphate of mercury being converted into proto-sulphate, by trituration with a further portion of the metal, sublimation with common salt, yields calomel directly.

Chlorine does not combine with mercury in the indirect mode, above mentioned, only. A jet of chlorine burns spontaneously in mercurial vapour, forming either, or both of the chlorides. The processes for manufacturing these important compounds of mercury, are very numerous. They have, however, but one object—that of presenting chlorine and mercury to each other in due quantities, and in a divided form. In proportion as the chlorine predominates, corrosive sublimate is formed; and, reversing the proportions, calomel.

Corrosive sublimate is soluble, both in water, and alcohol. Calomel is insoluble in both. Hot water dissolves much more corrosive sublimate than cold. Hence a saturated solution in boiling water, deposits crystals on cooling. Muriate of ammonia increases the solubility of corrosive sublimate, producing with it a combination, formerly called *sal alembroth*.

Pure ammonia occasions a white precipitate from the solution of the deuto-chloride, called, in the pharmacopœias, *hydrargyrum, precipitatum album*.*

* According to an analysis of Fourcroy, founded on the idea of chlorine being oxygenated muriatic acid, this precipitate contains 81 parts of oxide of mercury, 16 parts of muriatic acid, and 3 parts of ammonia. Agreeably to the view now taken, it is therefore probable, that the ammonia takes chlorine from the mercury, and hydrogen from the water to form muriate of ammonia, which principally remains in solution; while the oxygen and mercury, liberated precipitate as oxide, together with a portion of proto-chloride of mercury and ammonia. The same precipitate is obtained, because the same precursory circumstances arise, on adding a fixed alkali to the solution of muriate of ammonia, and deuto-chloride of mercury. The alkali liberates from the muriate, ammonia, which then acts, as if added to a simple solution of deuto-chloride.

Heated together, mercury and iodine combine, forming either protiodide, or periodide, or both. Iodides are also produced from the nitrates, in the wet way, by the addition of the alkaline iodides, as chlorides are by addition of alkaline chlorides. The protiodide precipitates—the deutiodide, or periodide does not. Mercury combines with cyanogen. The compound is called cyanide, prussiate, or cyanuret of mercury. It is singular that the compounds formed with this factitious principle, and those formed with chlorine and iodine, should be analogous.

Mercury with sulphur forms two compounds, which are black or red, according to the proportions, and the process.

The black compound has been called Ethiops mineral, the red, cinnabar.

Ethiops mineral is made by heating and triturating one part of mercury with three of sulphur; cinnabar, by the fusion and sublimation of five parts of mercury, with one of sulphur. Cinnabar has also been formed by triturating the black sulphuret, with a solution of the caustic potash. Sulphuretted hydrogen deoxidizes the mercury, in mercurial salts, and separates it as a sulphuret. It is precipitated from its solution, in nitric acid, by borates, arsenites, arseniates, chromates, and phosphates.

All metals combine with mercury, directly or indirectly. The compounds have the generic name of amalgam. In the case of gold, silver, zinc, lead, tin, and bismuth, the amalgamation is rapidly effected. It is less easily produced with copper, unless when this metal separates mercury from the acids. It is difficult to unite mercury with platina, and still more so with iron; owing probably, to the great difference in fusibility.

Mercurial compounds are all volatilizable by heat, and mercurial salts, when moistened and rubbed on copper, cover it with a film of mercury.

OF FULMINATING MERCURY.

EXPERIMENTAL ILLUSTRATIONS.

Ebullition and distillation of mercury. Its compounds with oxygen and sulphur exhibited. Action of nitric

acid, and of sulphuric acid, on the metal. Resulting salts subjected to hot water. Black oxide, and red oxide, severally dissolved in nitric acid. Muriatic acid precipitates calomel from the one, but occasions no precipitate in the other. Alkalies produce a black precipitate in the nitrate of the black oxide, or protoxide; an orange precipitate in the nitrate of the red oxide or deutoxide. Similar results obtained, by adding them to calomel and corrosive sublimate; the first giving the black, the last the red oxide. Inflammation of chlorine with mercurial vapour. Explosion of fulminating mercury.

OF COPPER.

Copper is found nearly pure in nature. The copper of commerce contains, according to Berzelius, about one half of a grain of sulphur and carbon, in one hundred grains.

MEANS OF OBTAINING PURE COPPER.

Copper may be purified by solution in concentrated boiling muriatic acid, and subsequent precipitation by a bright plate of iron.

The colour, and lustre of this metal, are well known. Its specific gravity is nearly 9. It is very malleable, very ductile, and tenacious. It fuses at a low white heat. It oxidizes slightly by exposure to air; and its oxidization is not much aided by exposure to moisture. At a red heat it oxidizes rapidly, being converted into protoxide, which scales off, if it be afterwards hammered. By further calcination, it is reduced to the state of black oxide, or peroxide. The precipitate from nitrate of copper, by potash, being exposed to a red heat, forms the peroxide.

Copper, in thin leaves, takes fire in chlorine, and forms two chlorides—a fixed proto-chloride, and a volatile per-chloride. The per-chloride, when dry, is of a faint yellow colour, but if moistened becomes green; hence it acts as a sympathetic ink, rendered visible by the breath.

Hydriodic acid precipitates copper from its solutions, in the state of an insoluble iodide.

Nitric acid, diluted with three parts water, peroxidizes and dissolves copper. The solution is of a bright blue. It forms elegant blue deliquescent crystals, which moistened and rolled up in tin foil, ignite it. Heated, they pass to the state of sub-nitrate, of the deutoxide. Sulphuric acid boiled on copper, oxidizes and dissolves it, as does nitric acid in the cold. The sulphate resulting, forms beautiful blue crystals, called in commerce blue vitriol. This salt is obtained also by the torrefaction of the sulphuret of copper, and subsequent exposure to moisture and air.

Alkalies combine with the oxide of copper, and with the salts of this metal. Ammonia especially dissolves its oxides; and when they are united to acids, produces triple salts by its union with the compounds. Cuprum ammoniatum is formed, by triturating sulphate of copper with sub-carbonate of ammonia.

OF VERDIGRIS, OR SUBACETATE OF COPPER.

OF CRYSTALS OF VENUS, DISTILLED VERDIGRIS OR ACETATE OF COPPER.

Carbonate of copper is produced, when copper is precipitated from its solutions by alkaline carbonates. It forms on copper, when exposed to moist air. It is found native, in various forms remarkable for beauty.

The oxides of copper are susceptible of combination with the acids. Alloyed with a small quantity of tin, it forms bronze, with a larger, bell metal. Fused with zinc, or subjected to the vapour of an ore of this metal, it is converted into brass.

EXPERIMENTAL ILLUSTRATIONS.

Solution of copper and its precipitation by iron. Effect of ammonia: also of ferro-prussiate of potash.

OF IRON.

The mechanical qualities of this metal are too well known to need description. It is one of the most generally distributed principles in the creation, and probably

the most universal colouring matter. It combines greedily with oxygen, forming a black oxide, and a red oxide, and probably others which are of minor importance. Ores of iron are principally of the black, or the red oxide. The black oxide is magnetic; the other may be rendered magnetic, by exposure on charcoal to the blowpipe. The rust of iron is red oxide, combined with more or less carbonic acid. The finery cinder, which flies off from incandescent iron in forging, is the black oxide. This oxide is formed rapidly, when iron wire is ignited in oxygen gas; also, when steam is passed over the metal while white hot. The quantity of oxygen in red oxide, to the quantity in black, is as three to two. Water combines chemically with these oxides, forming hydrates. Ochre is a hydrate, mixed with earthy matter.

Iron is oxidized and dissolved, when subjected either to diluted muriatic, or sulphuric acid. The metal is at first in the state of black oxide, but passes to that of red oxide, by absorbing the oxygen of the air. The green muriate evaporated to dryness, forms a proto-chloride. The per-chloride is formed by the combustion of iron in chlorine gas.

Nitric acid oxidizes iron, and dissolves the oxide, as in the case of other metals.

Acetic acid causes iron to absorb oxygen slowly, and dissolves the oxide as produced.

The red oxide of iron combines with carbonic acid, and is soluble in water impregnated with this gas.

There are two native sulphurets of iron, a proto-sulphuret and a deuto-sulphuret. The former only is magnetic, but the latter may be rendered magnetic by roasting, or exposure before the blowpipe, by which it loses one proportion of sulphur, and passes to the state of proto-sulphuret. It is the proto-sulphuret which is formed by the combustion of iron with sulphur. Iron filings and flowers of sulphur, moistened with water, after some time take fire. Heated, they incorporate, with the appearance of combustion.

An iron bar at a welding heat, if touched with a roll of brimstone, falls instantly in drops of melted proto-sulphu-

ret, and an iron wire burns brilliantly when exposed to a jet of sulphur in vapour, as it issues from the touch-hole of a red hot gun-barrel, as I have recently ascertained.

Iron combines with phosphorus. The presence of this substance in a small proportion, renders it brittle while red hot.

With carbon, iron combines in various proportions, forming steel, cast iron, and plumbago. Plumbago consists of carbon, combined with about six per cent. of iron. It is very difficult of fusion and combustion. It was first fused by me in 1802. The finest kind is seen in the best English pencils. Plumbago of an inferior kind, is used as a material for crucibles and small furnaces.

Cast iron contains not only carbon, but silicon, sulphur, and phosphorus, and probably sometimes calcium. It is purified by long continued fusion, frequent stirring, and subsequent hammering.

Pure malleable iron, thus obtained, is converted into steel by being heated in contact with charcoal in ovens without access of air. The process is called cementation. The bars are blistered by the operation, as they are seen in commerce. Broken up and welded again, they form shear steel. Fused, they form cast steel. It has lately been advanced, that silicon is a more necessary ingredient in steel, than carbon, and that wootz, or Indian steel, owes its excellence to aluminum as well as silicon.

The hardening or tempering of steel and cast iron seems to depend on crystallization. The specific gravity is lessened by the hardening.

ON PERKINS'S PROCESS FOR DECARBONIZING STEEL, AND RECARBONIZING THE IRON OBTAINED.

ON HARDENING AND ANNEALING MALLEABLE METALS IN GENERAL.

ALLOYS OF STEEL WITH RHODIUM, PLATINUM, AND SILVER.

ON TINNING, AND TIN PLATE.

ON THE TESTS FOR IRON.

Iron, in the state of red oxide, is precipitated blue by ferro-prussiate of potash; purple or ink coloured by in-

fusion of galls or other astringent vegetables, and brown by succinates, or salts formed by the acid of amber.

There are four principal classes of ferruginous minerals. Magnetic black oxides, and red oxides not magnetic.* Magnetic proto-sulphurets, and deuto-sulphurets not magnetic. Hence the ores of iron, if not obedient to the magnet, generally become so, after exposure on carbon to the blowpipe, by which the excess of oxygen, or sulphur, which destroys the magnetic power, is expelled.

EXPERIMENTAL ILLUSTRATIONS.

Iron dissolved by muriatic and sulphuric acids. Red and black oxides of iron, and their solutions, exhibited: precipitated by galls, and by ferro-prussiate of potash. Effects of muriate of tin on the colour of the precipitates. Iron burned in oxygen gas; also, by sulphur, and by galvanism. Ores rendered magnetic by the blowpipe.

OF NICKEL.

The colour of nickel is white. It is magnetic; difficult of fusion; malleable; and not easily oxidized by the air. If it could be procured in sufficient quantities, it would be very valuable in the arts. It combines with oxygen, chlorine, iodine, sulphur, and metals. Its oxides are soluble in the acids. Its habitudes with them, are much like those of copper. The solubility of its protoxide in caustic ammonia, is an important mean of separating it from its alloys.

OF TIN.

It is sold in commerce under the name of block tin, to distinguish it from tinned iron plates. In utensils newly made of these, its colour and lustre are seen. It tarnishes slightly by exposure. It is very malleable and ductile. Its specific gravity is 7.9. Excepting bismuth, selenium, and mercury, it is the most fusible metal. It melts at 442° F. Tinfoil is $\frac{1}{160}$ of an inch thick. Tin is distinguished by producing a peculiar crackling noise, when its ingots are bended, to and fro. It forms two oxides

* Considering the number of the oxides of iron doubtful, I designate them by their colour.

and two chlorides. The deuto-chloride is a very singular fuming liquid. A small quantity of water congeals it; but a larger, restores its fluidity. This chloride has long been known by the name of the fuming liquor of Libavius. The protoxide of tin is soluble in diluted nitric acid. In strong acid, it becomes peroxidized, and, in that state, is not soluble. Boiling sulphuric acid, whether strong or weak, converts it into a protoxide, and dissolves it. Solutions of the nitrate, or sulphate, absorb oxygen, and deposite the peroxide, in a state of subsulphate, or subnitrate. Muriatic acid is its proper solvent; and the compound produced, is usually considered as the muriate of the protoxide. This solution absorbs oxygen, and deoxidizes oxides, in other solutions. Hence it precipitates gold, and platina, and hence it destroys the colour of ink, and Prussian blue. It is always acid.*

Nitro-muriatic acid dissolves tin with violence, producing much heat, and forming a perchloride in solution. Tartaric acid dissolves tin. Brass and copper are tinned slightly by boiling them with powdered or leaf tin and cream of tartar. When cleaned and immersed in melted tin, with addition of oil or rosin, to prevent oxidizement, they become covered with a coat of the fused metal.

Tin forms two sulphurets. The persulphuret is of a golden colour, and was known formerly as aurum musivum.

OF BRONZE, OF BELL-METAL, OF SPECULUM-METAL, OF PEWTER.

OF LEAD.

The colour, lustre, and malleability of this metal are well known. It fuses at about 600° F. Its specific gravity is 11.352. It is the most ductile metal in large masses, as it may be drawn into pipes of four inches bore, but it is too deficient in tenacity, to be drawn into fine wire. It is very useful to chemists, being employed in the manufacture of sulphuric acid and chlorine. Lead tubes and vessels are not easily injured by moisture, or acid fumes.

* This does not arise from an excess of acid, as there is none in it which is not essential to the compound. Hydrogen, oxygen, and chlorine are present, and though tin be combined with them, it does not totally destroy those attributes of acidity, which they otherwise display when united.

Two oxides of lead are usually met with in commerce. One containing eight per cent. of oxygen, is called massicot, or when vitrified, litharge. The other containing twelve per cent. of oxygen, is called minium or red lead, from its colour.

A peroxide of lead, of a puce colour, is obtained by exposing red lead, suspended in water, in an impregnating apparatus, to chlorine gas.*

Lead is oxidized and dissolved, when subjected to nitric acid. Neither sulphuric, nor muriatic acid, has any action on it, when cold. Sulphuric acid, when boiling and concentrated, oxidizes, and combines with it, forming an insoluble sulphate.

Lead is also oxidized and dissolved by acetic acid, and forms a soluble acetate, and sub-acetate. The acetate is called in commerce, Sugar of Lead.

When exposed to the fumes of vinegar, which consist of acetic acid, and carbonic acid gas, lead is oxidized by the acetic acid, and combines with the carbonic acid, forming ceruse, or the white lead of commerce.

Chlorine combines with lead, but the resulting chloride, being fixed and insoluble, protects the metal from further erosion. Hence the utility of leaden vessels, in manufacturing chlorine in the large way.

The most prolific ore of this metal, is the sulphuret, called galena. Exposed to the blowpipe, the sulphur of galena is driven off, and the metal appears in a globule.

Lead is precipitated from its solutions by sulphates, chromates, phosphates, and muriates; and its presence in very small quantity, is shown by sulphuretted hydrogen.

EXPERIMENTAL ILLUSTRATIONS.

Solution of lead in nitric acid. Its solutions precipitated by sulphates, muriates, phosphates, and chromates.

* The greenish-gray powder, formed on lead when fused under ordinary circumstances, has been alleged by the celebrated Proust, and other chemists, to be a mixture of massicot, with metallic lead. Minium is alleged to be a mixture of massicot, with puce oxide. It seems to me more reasonable to suppose the gray powder, the protoxide; massicot, the deutoxide; minium, the tritoxide, and the puce oxide, the peroxide. Ceruse is admitted to be a compound of massicot with carbonic acid. Yet I found the dross of lead, after long exposure to that acid, to yield no ceruse.

Also by sulphuretted hydrogen. Precipitation of carbonate of lead, from the sub-acetate, by the carbonic acid of the breath. Galena decomposed by the blowpipe flame.

OF ZINC.

This metal is best known in commerce, under the name of Speltre, or Spelter. It is usually adulterated by lead and sulphur; and sometimes by a metal lately discovered, called Cadmium. It may be obtained, pure, by allowing diluted sulphuric acid to act on an excess of the metal, when the zinc will be taken up in preference. The oxide is to be precipitated from this solution by pearl-ash, and the metal revived by ignition with charcoal.

PROPERTIES OF ZINC.

Its colour is brilliant white, slightly tintured with a leaden hue. Its specific gravity is about 6.86, being, excepting the metalloids, among the lightest of the metals. Under ordinary circumstances, it is not malleable, but may be laminated by rollers, at a heat somewhat above boiling water. It melts at about 680° F. Its structure is strikingly crystalline. It is slightly oxidized by exposure to the atmosphere; but at a white heat, burns rapidly, giving off fumes of oxide. This is the only known oxide of zinc, and consists of about 80 parts metal, and 20 oxygen.

Water is rapidly decomposed, when passed in the state of steam over ignited zinc, or when presented to it together with a due proportion of sulphuric, or muriatic acid. This affinity of zinc for oxygen, renders it of great use in galvanic operations, as it possesses a polarity opposite to copper, silver, and other less oxidizable metals; and hence, when associated with them, produces the most efficient series, which can be constructed, without using silver, gold, or platina, which are too expensive.

Zinc is soluble in nitric and muriatic acids, being oxidized by the water in the one case—in the other, at the expense of a portion of the nitric acid. It forms a chloride, when subjected in a divided state to chlorine gas.

This chloride has been called, from its consistency, butter of zinc.

Acetic acid may be combined with zinc, by mixing its sulphate, with acetate of lead.

Brass is an alloy of zinc with copper.

EXPERIMENTAL ILLUSTRATIONS.

Zinc subjected to diluted sulphuric, and diluted muriatic acids, severally. Solutions precipitated by acetate of lead. Combustion of the metal in an incandescent crucible. Its habitudes with the blowpipe.

OF BISMUTH.

This metal is found in commerce in a state of sufficient purity. Its fracture is crystalline, like that of zinc and antimony; but a peculiar blush distinguishes it. Its specific gravity is 9.822. It is not malleable. Excepting selenium, mercury, tin, and the metalloids, it is the most fusible metal. Its fusing point is 476° F. It is oxidized, when kept in fusion in the air.

Subjected to sulphuric acid, bismuth is partly dissolved, and partly converted into an insoluble oxide.

Nitric acid dissolves bismuth, and forms a compound, which, when added to water, yields an insoluble hydrated oxide, called magistery of bismuth, or pearl white.

Bismuth, when subjected, in a divided state, to chlorine gas, takes fire, and forms a chloride.

Most of the metals may be alloyed with bismuth. Eight parts of this metal, with five of lead, and three of tin, form a compound fusible in boiling water.

Bismuth is used in solder, to render it more fusible.

PRACTICAL ILLUSTRATIONS.

Bismuth and its oxide exhibited. Its hue and habitudes with the blowpipe, compared with those of zinc, antimony, and arsenic.

OF ANTIMONY.

This metal, in the state of regulus, has become an object of commerce, on account of its utility as an ingredient in type-metal, and in pewter.

PROPERTIES OF ANTIMONY.

It is crystalline in its fracture, and of a very fine silver white. It does not tarnish much in the air. It is neither malleable, nor ductile. Before the blowpipe, it fuses at a low red heat, and oxidizes rapidly, and if thrown upon a board, while melted, is dispersed in red hot globules, whose temperature appears to be sustained by their combustion.

The information given by different chemists, on the subject of antimony, is very discordant. According to Berzelius, there are four oxides. According to Proust, and Brande, there are only two. Henry considers the argentine flowers, which volatilize during combustion, as the peroxide, while Brande alleges that they are the protoxide. Dr. Ure informs us, that antimony forms four oxides, probably—certainly three; and that the deut-oxide of Berzelius is the efficient oxide, which enters into the most useful preparations.

There seems a coincidence between these chemists, so far as this, that the medicinally efficacious antimonial oxide, is that which may be precipitated from a solution of antimony in muriatic acid, by an alkali, or which is obtained by boiling sulphuric acid on the metal to dryness. The oxide thus obtained, by sulphuric or muriatic acid, appears to be the same as that which exists in tartrate of potash and antimony, (tartar emetic), however this triple compound may be made.

Hence the protoxide of Brande, or deutoxide of Ure, the *oxidum antimonii* of the pharmacopœias, may be obtained by adding to a solution of tartrate of potash and antimony, subcarbonate of ammonia, and boiling the mixture till the oxide precipitates.

The peroxide of antimony is formed by igniting powdered antimony, with six times its weight of nitre. The compound is attractive of alkalies rather than of acids; and therefore may be considered as belonging to the latter class. It is alleged to be inert, medicinally.

There is an oxide of antimony produced, by dissolving the metal in nitric acid, evaporating to dryness, and igniting the residuum. This, by Berzelius, Ure, Henry,

and others, is considered as an intermediate oxide, between that obtained by muriatic or sulphuric acid, or from emetic tartar, and the peroxide (or acid) procured by the action of nitre. It is alleged to have acid properties, and to be the same compound, as the precipitate produced in a nitro-muriatic solution of antimony, by the addition of water. This precipitate has been called powder of Algaroth. It is obtained, when chloride of antimony is thrown into water. The formation of this chloride was shown, in order to illustrate the properties of chlorine as an agent in combustion. Pulverized antimony was spontaneously ignited, in falling through the gas, and chloride, or butter of antimony, formed. The same compound results from the distillation of corrosive sublimate, with antimony in powder.

Sulphur and antimony exercise a powerful affinity for each other. This metal exists most abundantly in nature, in the state of sulphuret. It is thus found in commerce, under the name of crude antimony; while the metal, as used by type-founders, is called regulus of antimony. To obtain antimony from its sulphuret, we are directed to ignite two parts of it, with one of iron filings, and half a part of nitre. The sulphur having a greater affinity for iron, leaves the antimony for this metal, and the nitre probably oxidizes any excess of the sulphur. In order to complete the purification, the impure antimony, thus obtained, must be dissolved in nitro-muriatic acid, and the compound produced subjected to water:—the oxide resulting, is then revived by ignition with crude super-tartrate of potash.

When the sulphuret of antimony is roasted, under such circumstances, as to expel a portion of the sulphur, and partially to oxidize the metal; the residuum may be fused into a glass, containing, according to Henry, “eight parts of oxide, and one of sulphuret, with ten per cent. of silex.” If the quantity of sulphuret be doubled, a compound, called crocus metallorum, is obtained. The metal, in these compounds, is not peroxidized, and is probably in the same efficient state as in tartar emetic. When the sulphuret of antimony is boiled with potash, sulphu-

retted hydrogen is produced, by the decomposition of the solvent. This combines with the oxide, and forms a hydro-sulphuret of antimony, which precipitates. This hydro-sulphuret has long been known under the name of kermes mineral. After a solution, from which kermes has been precipitated, is cooled, an acid causes a further precipitation of oxide of antimony, combined with bi-sulphuretted hydrogen. The compound thus procured, may be deemed a sulphuretted hydro-sulphuret, and has been known under the name of golden sulphur of antimony.

Sulphuret of antimony, and boiled hartshorn shavings, roasted first, and afterwards ignited in a covered crucible to prevent the too great oxidizement of the metal, constitute the materials of James's powders, or the oxide of antimony with phosphate of lime, or *pulvis antimonialis* of the *pharmacopœias*.

According to Brande, the preparations sold under this name, vary, both with respect to the proportion of the ingredients, and the degree of oxidizement of the metal. According to Philips, they are often inert from containing peroxide only.* A solution of known quantities of phosphate of lime (or bone-earth) and of antimony, in muriatic acid, and precipitation by ammonia, has been proposed as a process, for making a preparation, of a more certain efficacy. It is however suggested, both by Brande and by Philips, that the tartrate of potash and antimony may be advantageously substituted, for every other antimonial medicine.

PRACTICAL ILLUSTRATIONS.

Antimony and its sulphuret exhibited and exposed to the blowpipe; also the crystals and solution of tartar emetic. Kermes mineral, and golden sulphur of antimony exhibited. Antimony subjected to acids.

OF ARSENIC.

This metal is sold in commerce under the name of cobalt, and is vulgarly known as fly-stone. In this state, as

* See *Annals of Philosophy*, for October, 1822.

it is very full of crevices, and exceedingly attractive of oxygen, it is difficult, even by a fresh fracture, to see the true colour or lustre of the metal. In order to obtain this object in perfection, the cobalt, (as it is absurdly named,) should be pulverized coarsely, and as much introduced into a glass tube, sealed at one end, as may not more than half fill it. The tube should be introduced into a cylinder of iron closed below. The but of a gun-barrel will answer. The space between the iron and the glass should be filled with sand, and another gun-barrel applied above, so as to catch the fumes, and conduct them up the chimney. That portion of the glass tube, which contains the arsenic, should be kept red-hot for about half an hour. After the apparatus is quite cool, the metal will be found in crystals of great splendour, occupying that portion of the glass tube, which was beyond the red heat.

Arsenic is distinguished from other metals, by its yielding white fumes, which have the odour of garlic, when exposed to the blowpipe, or placed on a hot iron. These fumes, however, might be confounded with those of antimony, by a person deficient of experience, were it not that the latter fuses, before it fumes, and thrown upon a board, after fusion, spreads itself abroad, in red-hot balls.

According to the opinion of Berzelius, which is adopted by Thenard, the black matter into which arsenic is converted, by exposure to the air, is a protoxide, and the fumes yielded by the combustion of the metal are the deutoxide. These fumes, condensed as they are evolved, on a large scale, during some metallurgic operations, constitute the white arsenic of the shops. By Henry, and many other chemists, white arsenic is considered as the protoxide, and they deem the black matter into which arsenic is converted by the action of the air, as a mixture of white arsenic with metallic arsenic. This conclusion appears irreconcilable with the fact ascertained by Berzelius, that the exposure of arsenic to air, never causes an absorption of more than eight per cent. of oxygen, while the white oxide contains thirty-two per cent. It seems very improbable, that, under the same circum-

stances, one portion of the metal should absorb thirty-two per cent. of oxygen, while, by another portion, none is absorbed.

There is also another combination of arsenic with oxygen, obtained by deflagrating the metal with nitre, or by digesting it with nitric acid. In this the oxidizement is admitted to be at a maximum. The white oxide of arsenic, and the peroxide, are also called arsenious and arsenic acids, as they combine with alkalies, and do not combine with acids.

Fowler's solution is made by boiling pearlash on the white oxide. It is an arsenite of potash. An arseniate is obtained, by deflagrating white oxide with nitre, agreeably to one of the processes of the Pharmacopœias.

Arsenic is found, in nature, in combination with sulphur, in different proportions. The compound containing the least sulphur, is of a fine red colour, and is called realgar; the other sulphuret is yellow, and is called orpiment. Either may be produced, according to the ratio of the ingredients, by distilling white arsenic with sulphur.

The arsenites, or arseniates, yield precipitates with solutions of copper or silver, and destroy the blue colour of the ioduret of starch. In the instances of copper and silver, arsenites or arseniates of those metals are formed. The arsenite of copper is of an apple green, called Scheele's green. The arsenite of silver is yellow.

In case of the ioduret, the iodine is neutralized by the arsenic.

OF ARSENURETED HYDROGEN.

OF THE MEANS OF DETECTING ARSENIC IN FOOD OR DRINK, OR IN THE CONTENTS OF A STOMACH, IN CASES WHERE POISONING IS SUSPECTED.

EXPERIMENTAL ILLUSTRATIONS.

Habitudes of arsenic, as obtained by sublimation, in its metallic crystalline form, contrasted with those of zinc, antimony, and bismuth; white oxide, and its solutions exhibited; also, Fowler's solution, or arsenite of potash. To large vessels of clear water measured

quantities of arsenic are added, and detected by various tests. Combustion of arsenuretted hydrogen displayed.

OF VARIOUS METALS OF MINOR IMPORTANCE.

OF RHODIUM, IRIDIUM, OSMIUM, COBALT, MANGANESE, CHROME, MOLYBDENUM, CERANIUM, TUNGSTEN, TELLURIUM, SELENIUM, TITANIUM, COLUMBIUM, OR TANTALUM, CERIUM.

ON VEGETABLE CHEMISTRY.

CHEMISTRY OF VEGETABLE AND ANIMAL SUBSTANCES, COMPARED WITH THAT OF INORGANIC SUBSTANCES.

OF THE ULTIMATE ELEMENTS OF VEGETABLE, AND ANIMAL SUBSTANCES.

OF THE PROXIMATE ELEMENTS OF VEGETABLE, AND ANIMAL MATTER.

ULTIMATE ELEMENTS, DISTINGUISHED FROM PROXIMATE ELEMENTS.

ON THE EFFECT OF IGNITION ON VEGETABLE SUBSTANCES.

OF THE DIFFERENCE BETWEEN VEGETABLE, AND MINERAL PRODUCTS, AS RESPECTS THEIR SYNTHESIS.

OF THE RELATION, OBSERVED BY THENARD, BETWEEN THE PROPERTIES OF VEGETABLE PRODUCTS, AND THE RELATIVE QUANTITY OF THEIR ULTIMATE ELEMENTS.

OF THE PRODUCTS OF THE DISTILLATION OF VEGETABLE MATTER IN GENERAL.

RATIONALE OF ITS DECOMPOSITION, WHEN IGNITED IN CLOSE VESSELS. ALSO OF ITS DECOMPOSITION, OR COMBUSTION, WHEN IGNITED IN THE OPEN AIR.

OF THE ACTION ON VEGETABLE MATTER.

OF CHLORINE AND IODINE.
OF THE ALKALINE METALLOIDS AND HYDRATES.
OF THE SULPHURIC, FLUORIC, AND FLUOBORIC ACIDS.
OF NITRIC ACID.

OF THE PROXIMATE ELEMENTS OF VEGETABLE MATTER

OF EXTRACT

OF MUCILAGE.

ON THE MUCILAGE {
 OF LINSEED.
 OF GUM ARABIC.
 OF CHERRY-TREE GUM.
 OF GUM TRAGACANTH.

OF SUGAR.

OF THE SLIGHT DIFFERENCE BETWEEN THE COMPOSITION OF GUM,
 AND SUGAR.

OF CRYSTALLIZABLE, AND UNCRYSTALLIZABLE SUGAR.

ON THE SWEET MATTER {
 OF HONEY.
 OF GRAPES.
 OF MOLASSES.
 OF GERMINATED GRAIN.
 OF LIQUORICE.

ON THE GENERAL PROPERTIES OF CRYSTALLIZABLE SUGAR.

ON THE ACIDS PRODUCED BY THE REACTION OF NITRIC ACID, WITH
 SUGAR.

OF MALIC ACID, OR THE UNCRYSTALLIZABLE ACID, WHICH PRE-
 DOMINATES IN THE APPLE, IN GOOSEBERRIES, CURRANTS AND
 SIMILAR FRUITS.

OF OXALIC ACID, OR THE CRYSTALLIZABLE ACID, OF THE
 OXALIS ACETOCELLA.

OF THE CITRIC ACID, OR ACID OF THE LEMON.

OF GALLIC ACID, OR ACID OF GALLS.

OF GALLIC ACID IN UNION WITH TANNIN.

OF SORBIC ACID—OF TARTARIC ACID—OF KINIC ACID—OF
 BENZOIC ACID.

OF THE COMPOUNDS OF BENZOIC ACID, CALLED BALSAMS.

OF THE PRUSSIC, AND PHOSPHORIC ACIDS, AS VEGETABLE PRODUCTS.

OF THE FIXED, OR FAT, OILS.

DISTINGUISHED FROM VOLATILE OILS. GENERAL PROPERTIES.

ON THEIR COMBINATIONS WITH ALKALIES—WITH SULPHUR.

ON THE MEANS OF RENDERING OILS DRYING.

ON THE PRODUCTS $\left\{ \begin{array}{l} \text{OF THEIR DISTILLATION.} \\ \text{OF THEIR COMBUSTION IN THE AIR.} \end{array} \right.$

ON THE ACTION OF NITRIC ACID, AND OF CHLORINE, ON OILS.

ON THE SPONTANEOUS COMBUSTION OF THE DRYING OILS, WITH CARBONACEOUS MATTER, OR WITH COTTON : ALSO WITH ASHES.

ON THE SEPARATION OF OILS, BY COLD OR BY ALCOHOL, INTO A SUBSTANCE, LESS FUSIBLE, CALLED STEARIN, AND INTO ONE OF GREATER FUSIBILITY, CALLED ELAIN.

ON THE ACIDIFICATION OF STEARIN, AND ELAIN, DURING SAPONIFICATION, PRODUCING THE MARGARIC, AND OLEIC ACIDS.

OF THE VOLATILE OILS.

ON THE MEANS OF PROCURING THE VOLATILE OILS.

ON THE OILS OBTAINED BY EXPRESSION—BY DISTILLATION WITH WATER. RATIONALE OF THEIR GENERAL PROPERTIES.

ON THEIR REACTION $\left\{ \begin{array}{l} \text{WITH ALKALIES.} \\ \text{WITH ACIDS.} \\ \text{WITH CHLORINE AND CHLORATES.} \end{array} \right.$

ON THE THICKENING OF OILS, WHETHER FIXED OR VOLATILE, BY EXPOSURE TO AIR, AND ON THE NOXIOUS EXHALATION OF PAINTED ROOMS.

OF CAMPHOR, A CONCRETE VOLATILE OIL.

ON ITS PECULIAR SUSCEPTIBILITY OF BEING ACIDIFIED BY NITRIC ACID, INSTEAD OF BEING INFLAMED, LIKE OTHER VOLATILE OILS.

ON THE SOLUTION OF CAMPHOR IN ACIDS—ON ITS DECOMPOSITION BY SULPHURIC ACID.

OF ARTIFICIAL CAMPHOR.

OF RESINS.

RESINS DEFINED.

ON THE GENERAL PROPERTIES OF RESINS—THEIR HABITUDES WITH WATER, ALCOHOL, OILS, ALKALIES, AND ACIDS.

OF FECULA, OR STARCH.

ON THE MODE OF SEPARATING FECULA FROM FARINACEOUS MATTER; ALSO FROM ROOTS OF PLANTS, AS, FOR INSTANCE, FROM THE POTATOE.

ON THE HABITUDES OF FECULA WITH IODINE, AND WITH WATER.

ON THE CONVERSION OF STARCH INTO SUGAR, BY SULPHURIC ACID.

ON THE HABITUDES OF FECULA: $\left\{ \begin{array}{l} \text{WITH SUBACETATE OF LEAD.} \\ \text{WITH ALKALIES.} \end{array} \right.$

OF GLUTEN.

ON THE MODE OF OBTAINING GLUTEN FROM WHEAT FLOUR, BY WASHING AWAY THE FECULA.

ON THE RESEMBLANCE OF GLUTEN TO ANIMAL MATTER, IN YIELDING AMMONIA BY DISTILLATION.

ON THE NECESSITY OF GLUTEN TO THE RISING OF BREAD.

OF CAOUTCHOUC.

OF LIGNIN.

OF TANNIN.

ON THE AFFINITY OF TANNIN FOR GELATINE, AND ITS CONSEQUENT UTILITY IN TANNING, AND IN THE CLARIFICATION OF LIQUORS.

ON THE UNION OF TANNIN WITH GALLIC ACID, AND MEANS OF SEPARATING THEM.

OF ARTIFICIAL TANNIN.

OF WAX, A CONCRETE FIXED OIL.

ON ITS PREVALENCE IN THE COVERINGS OF LEAVES, FRUITS, AND THE POLLEN OF FLOWERS.

ON THE PRODUCTION OF WAX BY BEES, CONFINED TO A DIET OF SUGAR.

ON THE BLEACHING OF WAX.

ON THE HABITUDES OF WAX	{ WITH WATER. WITH ALCOHOL. WITH ETHER. WITH ALKALIES. WITH ACIDS.
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OF AMER; A PECULIAR BITTER, NARCOTIC, AND ANTISEPTIC PRINCIPLE, FOUND IN CERTAIN VEGETABLES, THE HOP ESPECIALLY.

OF THE NARCOTIC PRINCIPLE OF OPIUM, OR MORPHIA.

OF CORK, WHICH HAS BEEN DEEMED A PECULIAR VEGETABLE PRINCIPLE.

OF BITUMEN, A SUPPOSED VEGETABLE PRODUCT OF A FORMER WORLD.

OF PICROTOXIN, OR THE NARCOTIC PRINCIPLE OF COCCULUS INDICUS.

OF NICOTIN, OR THE NARCOTIC PRINCIPLE OF TOBACCO.

OF EMETIN, OR THE ACTIVE PRINCIPLE OF IPECACUANHA.

OF THE VINOUS FERMENTATION.

When certain vegetable infusions, or mixtures of saccharine and farinaceous matter, or the juices of fruits, as those of the apple or grape, are kept at a temperature not above 120° F. nor below 55° , a chemical reaction arises. The particles of water, the presence of which is essential to the process, are decomposed; the oxygen combines with a portion of the carbon of the fermenting matter, and escapes in the form of carbonic acid gas, while the ratio of the hydrogen is increased in the residue, and a new fluid compound is constituted, in which hydrogen predominates. This fluid compound is alcohol, or spirit of wine; to which the intoxicating power of fermented liquors is due.

ON THE ACTION OF FERMENTS, OR YEAST.

By distillation, the alcohol in fermented liquors, is separated, as it boils at a lower temperature than water. It still contains, however, more or less of this fluid, and though depurated from it to a considerable degree, by repeated distillations, it requires the chemical affinity of pearlash, or some other substance attractive of moisture, to bring it to the highest possible degree of strength, in which its specific gravity is, to that of water, nearly as 800 to 1000.

The union between alcohol and water is so energetic, as to cause a rise of temperature, and a diminution of volume, when they are mixed.

Alcohol, by combustion, yields only water and carbonic acid. It is more expansible than water, and boils at 176° F. The capacity of its vapour, for heat, is much

less than that of water. It has never been frozen. It is a powerful solvent, and a most useful agent, in pharmacy, and in the delicate analysis of vegetable and animal matter. I have ascertained that the addition of one-seventh of oil of turpentine, will render its flame so luminous, as to be a competent substitute for a candle flame.

Alcohol is alleged to consist of equal volumes of olefiant gas, or bi-carburetted hydrogen gas, and aqueous vapour. When passed through a copper, or porcelain tube, it yields carburetted hydrogen, and aqueous vapour.

EXPERIMENTAL ILLUSTRATIONS.

Mixture of alcohol and water—change of temperature noted. Brande's apparatus for demonstrating loss of bulk, exhibited. Powers of alcohol as a solvent, contrasted with those of water.

OF SULPHURIC ETHER.

When equal weights of alcohol and sulphuric acid, are mixed and distilled, a fluid known by the name of sulphuric ether, is produced. If the distillation be continued long enough, the fumes of sulphurous acid, a peculiar oil, and alcohol containing this oil, together with water and acetic acid, pass over—till at last the mass swells up, so as to render it necessary to terminate the process.

The ether may be washed in water, in which a small quantity of red lead, or manganese, has been introduced, to remove the sulphurous acid. A little liquid ammonia, diluted with water, purges the fluid, of this acid, instantly. The whole should be subjected to distillation, by means of a water bath heated to 120° , to separate the ether; and afterwards raised to a boiling heat to obtain the alcohol and sweet oil of wine, or Hoffman's anodyne liquor.

Ether is very light—being in specific gravity to water, nearly as 700, to 1000. It is very volatile. Its power of freezing water, by its evaporation in air, and its ebullition in vacuo, has been illustrated during the first part of this course of instruction. It boils at 98° F. under the pressure of the atmosphere—and, in vacuo, below the freezing

point of water. Ether partially combines with water, but unites with alcohol in any proportion. It freezes at -46° F. It has peculiar and useful powers as a solvent.

Ether is supposed to consist of bi-carburetted hydrogen, and aqueous gas—but that the proportion of the aqueous gas, is the half of that in alcohol.

OF THE IMPURITY OF THE ETHER AND THE HOFFMAN'S AN ODYNE OF THE SHOPS.

OF NITRIC ETHER.

OF SWEET SPIRITS OF NITRE.

OF MURIATIC ETHER.

OF THE THREE DISTINCT GENERA OF ETHERS.

RATIONALE OF ETHERIFICATION IN GENERAL, AND OF EACH PROCESS IN PARTICULAR.

EXPERIMENTAL ILLUSTRATIONS.

Production and exhibition of sulphuric and nitric ethers. Apparatus for nitric ether, contrived by me, exhibited, and ether made by means of it.

OF THE ACETOUS FERMENTATION, AND ITS PRODUCT, THE ACETIC ACID.

ACETOUS FERMENTATION ERRONEOUSLY SUPPOSED TO REQUIRE THE ACCESS OF AIR.

VINOUS, ACETOUS, AND PUTREFACTIVE FERMENTATIONS, ALL DETERMINED, IN A MANNER ANALOGOUS, IN SOME DEGREE, TO THE COMMUNICATION OF DISEASE, BY INFECTION.

ON THE QUESTION, WHETHER THERE MAY NOT BE PECULIAR ANIMALCULES, WHICH GIVE RISE TO THE VINOUS, ACETOUS AND PUTREFACTIVE FERMENTATIONS, LIKEWISE TO THE EPIDEMICS ASCRIBED TO MIASMA.

OF PYROLIGNOUS ACID.

OF ACETIC ACID, FROM THE ACETATE OF COPPER, THE ACETATE OF LEAD, OR OTHER ACETATES.

ON THE PROPERTIES OF ACETIC ACID.

ON THE COMPOSITION OF ACETIC ACID.

OF SPIRIT OF MINDERERUS, OR ACETATE OF AMMONIA.

GENERAL CHARACTER OF THE ACETATES.

OF ANIMAL CHEMISTRY.

OF THE NECESSITY OF MAKING PROXIMATE ELEMENTS, THE OBJECTS OF ANALYSIS IN ANIMAL CHEMISTRY, NO LESS THAN IN THAT OF VEGETABLE SUBSTANCES.

ON THE ANALOGY BETWEEN THE POWERS OF AN ANIMAL GLAND, AND THOSE OF THE VOLTAIC PILE, IN ALTERING THE AFFINITIES OF MATTER.

THE VARIATIONS PRODUCED IN THE PROPERTIES OF ORGANIC PRODUCTS, BY DIVERSIFYING THE PROPORTIONS OF THEIR ULTIMATE ELEMENTS, ILLUSTRATED BY THE INFINITE VARIETY OF IMPRESSIONS PRODUCIBLE ON THE EYE, BY A FEW BEADS IN THE KALEIDOSCOPE; ON THE EAR, BY A FEW MUSICAL NOTES, AND ON THE MIND BY THE ARITHMETICAL DIGITS.

OF THE PRODUCTS OF ANIMAL MATTER WHEN SUBJECTED TO DESTRUCTIVE IGNITION.

OF THE DIVERSITY, IN THE PROPERTIES OF ANIMAL SUBSTANCES, CORRESPONDING WITH THE RELATIVE QUANTITIES OF THEIR ULTIMATE ELEMENTS.

OF FIBRIN, GELATIN, ALBUMEN, AND MUCUS, THE PRINCIPAL PROXIMATE ELEMENTS OF ANIMAL MATTER.

OF FIBRIN.

ON THE MEANS OF OBTAINING FIBRIN.

ON THE PROPERTIES OF FIBRIN.

ON THE PRODUCTS OF THE DISTILLATION OF FIBRIN.

ON THE CONSEQUENCES OF THE EXPOSURE
OF FIBRIN

TO WATER.
TO ALCOHOL.
TO ETHER.
TO VARIOUS ACIDS.
TO ALKALIES.

OF ALBUMEN.

ON THE COMPARATIVE PREDOMINANCY OF ALBUMEN, AND FIBRIN, IN
THE ANIMAL SYSTEM.

ON THE HABITUDES OF ALBUMEN

WITH HEAT.
WITH ALCOHOL.
WITH ACIDS.
WITH FIRE.
WITH WATER.
WITH GALVANISM.

ON THE COAGULATION OF ALBUMEN, AND ITS HABITUDES WITH ACIDS,
CORROSIVE SUBLIMATE, AND METALLIC SALTS. OF ALBUMEN AS
AN ANTIDOTE FOR POISONS. RATIONALE OF ITS ACTION IN CLARI-
FYING WINE OR SYRUP.

OF GELATIN.

WHERE TO FIND GELATIN.

GELATIN COMPARED WITH ALBUMEN.

ON THE HABITUDES OF GELATIN, WITH WATER. ON ITS PRECIPITA-
TION BY ALCOHOL, TANNIN, OR CHLORINE. ON ITS INSOLUBILITY
BY OILS, ALCOHOL, OR ETHER.

ON THE OPERATION OF GELATIN, IN FINING FERMENTED LIQUORS.

OF THE MANUFACTURE OF THE GELATIN OF COMMERCE, OR GLUE,
FROM SKINS. OF ICHTHYOCOLLA OR ISINGLASS. ALSO, OF THE
JELLIES OF CONFECTIONERS, AND PORTABLE SOUP.

OF MUCUS.

WHERE MUCUS EXISTS.

ON THE DIFFERENCE BETWEEN THE HABITUDES OF MUCUS AND ALBU-
MEN. OF THE HABITUDES OF MUCUS WITH CORROSIVE SUBLIMATE,
TANNIN, AND SUBACETATE OF LEAD.

OF UREA, OR THE CRYSTALLIZABLE MATTER OF URINE.

MEANS OF OBTAINING UREA.

OF THE PROPERTIES OF UREA.

OF THE COLOURING MATTER OF THE BLOOD.

OF ANIMAL RESINS.

OF OX BILE, AMBERGRIS, EAR WAX, CASTOR.

OF ANIMAL SUGAR.

ON THE SUGAR OF MILK. OF DIABETIC SUGAR.

OF ANIMAL OILS.

ANIMAL OILS COMPARED WITH VEGETABLE OILS—OF ADIPOCIRE—OF SUET, TALLOW, LARD—OF THE SEPARATION OF ANIMAL OILS, INTO ELAIN, AND STEARIN, BY ALCOHOL, OR BY BLOTting PAPER.

OF ANIMAL ACIDS.

OF THE ACIDS WHICH HAVE BEEN TREATED OF IN THE SECOND PART OF THE COURSE, BUT WHICH EXIST IN ANIMAL MATTER.

OF ACIDS PECULIAR TO ANIMAL MATTER.

OF URIC ACID, ALSO CALLED LITHIC.

OF SCHEELÉ'S DISCOVERY OF THIS ACID. WHERE URIC ACID EXISTS IN NATURE. MEANS OF OBTAINING URIC ACID. CHARACTERISTICS.

OF LACTIC ACID.

OF SACCOLACTIC ACID.

OF FORMIC ACID.

OF ROSACIC ACID.

OF AMNIOTIC ACID.

OF CHOLESTERIC ACID.

OF MARGARIC AND OLEIC ACIDS.

OF PRUSSIC OR HYDROCYANIC ACID.

OF CYANOGEN, THE BASE OF PRUSSIC ACID, AS A PRODUCT OF THE INCINERATION OF ANIMAL MATTER, WITH AN ALKALI.

OF PRUSSIAN BLUE.

ON THE PROCESS FOR OBTAINING CYANIDE OF MERCURY, FROM PRUSSIAN BLUE.

MEANS OF OBTAINING PRUSSIC ACID.

PROPERTIES OF PRUSSIC ACID.

OF CHLOROCYANIC ACID, AND OF THE COMPOUND FORMED BY IODINE AND CYANOGEN.

OF THE MORE COMPLEX ANIMAL PRODUCTS.

OF THE BLOOD.

OF THE COMPOSITION OF THE BLOOD.

OF THE CHARACTERISTICS OR PROPERTIES OF THE BLOOD.

OF THE SEPARATION OF THE BLOOD, INTO SERUM, AND CRASSAMEN-
TUM.

OF THE SEPARATION OF THE SERUM, INTO COAGULABLE ALBUMEN, AND
INTO THE SEROSITY.

OF THE INFLUENCE OF THE FIXED ALKALIES IN RETARDING THE COA-
GULATION, AND OF THE ACIDS IN HASTENING IT.

OF THE PRECIPITATES PRODUCED IN THE BLOOD, BY METALLIC SALTS,
AND BY ALCOHOL.

OF THE DIFFERENCE OF COLOUR IN VENOUS, AND IN ARTERIAL BLOOD,
RESULTING PROBABLY FROM THE DECARBONIZATION OF THE BLOOD,
IN THE LUNGS, BY THE OXYGEN RESPIRED.

ON THE PROBABILITY THAT THE WARMTH OF THE BLOOD, MAY BE
PARTIALLY DUE TO RESPIRATION, BUT REFERABLE PRINCIPALLY TO
THE GENERAL LAW, THAT CORPUSCULAR REACTION CAUSES EITHER
AN ABSORPTION OR EVOLUTION OF CALORIC.

OF THE ANALOGY BETWEEN THE HEAT PRODUCED, BY FERMENTATION,
GERMINATION, AND VITALITY.

OF THE SALIVA.

OF THE MEANS OF OBTAINING SALIVA.

OF THE COMPOSITION OF SALIVA.

OF THE GASTRIC FLUID.

OF THE PROPERTIES OF THE GASTRIC FLUID.

OF THE PANCREATIC JUICE.

OF THE BILE.

OF THE COMPOSITION OF THE BILE.

OF CHOLESTERINE.

OF MILK.

OF THE DIVERSITY OF ITS QUALITIES, NOT ONLY AS PRODUCED BY DIFFERENT ANIMALS, BUT BY THE SAME ANIMAL, IN CONSEQUENCE OF CHANGES IN HEALTH OR FOOD.

OF THE COAGULATION OF MILK. OF THE INFLUENCE OF THE RENNET IN PROMOTING COAGULATION.

OF THE COMPOSITION OF MILK.

OF THE CHEESY, AND BUTYRACEOUS MATTER, WHICH, BEING SUSPENDED IN MILK, CAUSES ITS OPACITY, AND THE PELLICLE WHEN IT IS EVAPORATED.

OF THE DISTILLATION OF MILK, AND OF ITS COAGULATION BY ACIDS, AND BY ALCOHOL. OF THE EFFECT OF ALKALIES IN REMOVING COAGULATION.

OF THE COMPOSITION OF WHEY.

OF CHYLE, AND ITS INTERMEDIATE CHARACTER, BETWEEN MILK AND BLOOD.

COMPOSITION OF CHYLE.

OF THE MUCUS OF THE NOSE.

OF THE TEARS.—OF THE AQUEOUS AND VITREOUS HUMOURS OF THE EYE.

OF LYMPH.

OF SYNOVIA.

OF URINE.

OF THE COMPOSITION OF THE HUMAN URINE.

OF THE DIFFERENCE BETWEEN THE URINE OF CARNIVOROUS, AND THAT OF HERBIVOROUS ANIMALS, IN THERE BEING NO URIC ACID IN THE LATTER.

OF ANIMAL CALCULI.

OF THE DIFFERENT SPECIES OF CALCULI.

OF CALCULI CONSISTING CHIEFLY OF URIC ACID.

OF CALCULI CONSISTING OF AMMONIACO-MAGNESIAN PHOSPHATE.

OF CALCULI CONSISTING OF PHOSPHATE OF LIME.

OF CALCULI CHARACTERIZED BY OXALATE OF LIME.

OF CALCULI CONSISTING OF CYSTIC OXIDE.

OF CALCULI CONTAINING URATE OF AMMONIA.

OF CALCULI COMPOSED OF CARBONATE OF LIME.

OF CALCULI COMPOSED OF ZANTHIC OXIDE.

OF CALCULI IN WHICH VARIOUS SUBSTANCES ARE BLENDED.



OF SHELLS.

OF SHELLS OF A PORCELANOUS CONSISTENCY.—OF SHELLS CONTAINING CARTILAGINOUS MATTER.



OF HAIR—NAILS—EPIDERMIS—WOOL—CARTILAGE.

OF THE CUTIS, OR SKIN.



OF THE BRAIN.



CONCLUSION OF LECTURES ON THE CHEMISTRY OF VEGETABLE AND ANIMAL SUBSTANCES.



ON ELECTRICITY AND GALVANISM.

ON ELECTRICITY PROPER.

ON THE ORIGIN AND PROGRESS OF THE SCIENCE OF ELECTRICITY, FROM THE DISCOVERY OF THE ATTRACTIVE POWER PRODUCED IN AMBER BY FRICTION, UNTIL LIGHTNING AND THE ELECTRIC FLUID WERE IDENTIFIED BY THE OBSERVATIONS OF FRANKLIN.

EXPERIMENTAL ILLUSTRATIONS OF THE SCIENCE OF ELECTRICITY.

ON THE COMPARATIVE MERITS, OF THE THEORIES OF FRANKLIN AND DU FAYE.

EXPERIMENTAL ILLUSTRATIONS.

ON GALVANISM, OR VOLTAIC ELECTRICITY.

ON THE ORIGIN, AND PROGRESS, OF GALVANISM, OR VOLTAIC ELECTRICITY.

EXPERIMENTAL ILLUSTRATIONS.

ON THE VARIOUS THEORIES OF GALVANISM.

EXPERIMENTAL ILLUSTRATIONS.

In concluding the third and last Part of these Minutes it may be proper to state, that the order in which the subject has been treated, has not always been that which would have been chosen, independently of a desire, that it should correspond with the arrangement adopted in Henry's Chemistry, which had been recommended to the students as a text-book.

END OF PART III.

